SCIENCE ABSTRACTS.

Section A.—PHYSICS.

JULY 1915.

GENERAL PHYSICS.

794. *Duplex Harmonograph.* **J. H. Vincent** and **C. W. Jude.** (Phil. Mag. 29. pp. 490–514, April, 1915.)—Describes with full details the construction and use of a harmonograph in which the amplitudes and phases of the various motions are under control, little being left to the mere dexterity of the operator. Tisley's harmonograph draws the resultant of two simple harmonic motions at right angles to each other. The duplex harmonograph replaces each of these motions by the sum of two simple harmonic motions in the same straight line. A large number of harmonograms are reproduced, details being given of the frequency ratios required for them. A. W.

795. *Electrical Machine for Solving Numerical Equations.* **M. D'Aste.** (Lum. Élec. 29. pp. 197–198, May 29, 1915.)—Bethenod has dealt with the principle of an electrical machine for solving numerical equations [Abs. 628 (1915)]. In the present paper the author extends the idea by considering the types of equation susceptible of solution by a series of machines as suggested by Bethenod. He finds that it is theoretically possible to solve not only algebraic equations with numerical coefficients, but also linear differential equations with constant coefficients. A. W.

796. *Simple Apparatus for Tidal Analysis.* **E. W. Brown.** (Am. J. Sci. 39. pp. 386–390, April, 1915.)—A description of an apparatus for the analysis of tidal observations which is both simple and inexpensive. Darwin's well-known apparatus has disadvantages which he himself recognised. It consisted of strips of xylonite on which the observations were written, and of guide-sheets carefully printed to show the positions in which the strips were to be placed for the evaluation of any particular tide. These were made for a year's observations and about a dozen different periods; each sheet was to serve for 74 days, and there were thus some 60 large sheets to be used. In the new arrangement the strips are replaced by endless paper bands, and the guide-sheets by simple instructions for arranging the bands and for testing the correctness of the arrangements. The successful use of the apparatus depends mainly on small details, which are fully dealt with. Twelve sheets contain all the observations, which may be written in as they are measured from the tide curve; and finally the whole year's observations are contained on bands stretched over ten cards. The method of manipulating these is described. A. W.

797. *Gyroscopic Compasses.* **E. K. Scott.** (Inst. Marine Eng., Trans. 26. pp. 235–281; Disc. 282–297, Dec., 1914.)—After dealing at some length with the Anschütz and the Sperry forms of gyroscopic compass the author describes a new type of gyro-compass, devised by V. H. Rozic and himself, called the "Sea Star" compass. It is not possible to give a clear idea of the arrangements without the diagrams given in the original; but the compass has several special features which may be mentioned. Thus, it is an attempt to make the righting momentum not depend on gravity for its magnitude, but to be always determined by the amount of deflecting momentum that has to be counteracted. Further, the gyro-wheel is so mounted that it is non-pendular about its horizontal axis, and therefore not subject to ballistic effects. L. H. W.

798. *Simple Method of determining Radius of Curvature of Spherical Surfaces.* **W. C. Baker.** (Nature, 95. p. 288, May 13, 1915.)—The small lens or other object to be tested rests on a ring on a little frame. A small three-legged optical lever is then placed in two positions whose spacing s is fixed by the arrangement of the frame and can be measured by a microscope. The angle θ corresponding to these two positions is noted by the optical lever; hence the radius desired is given by $\rho = s/\theta$. E. H. B.

799. *Acoustic Method for determining Elastic Constants of Plates.* **A. Kalähne.** (Deutsch. Phys. Gesell., Verh. 17. 2. pp. 35–44, Jan. 30, 1915.)—From the formulæ for the natural vibrations of a plate it is seen that the ratios of the frequencies of the different tones depend only on Poisson's ratio μ, and not at all on Young's modulus E. From a determination of the ratios of the frequencies of two or more tones, therefore, μ may be deduced and then E may be found from the absolute value of one of these. If the plate is circular and homogeneous, then the frequency of a tone with p nodal lines and h nodal circles is given by $N_{ph} = (\beta R/2)^2(\delta/R2\pi)\sqrt{E/3\rho(1-\mu^2)}$, where ρ, R, and δ are respectively the density, radius, and thickness of the plate while $\beta R/2$ is a coefficient depending on the particular tone and is therefore a function of ph and μ. Curves are given showing for various different values of p and h the relation between this coefficient and the value of μ. The actual measurements of the frequencies may be made with great accuracy. Owing to lack of homogeneity in the material or of regularity in form, each set of nodal curves will generally correspond to two slightly different tones. The periods of these having been measured, the mean value must be taken as the true one. To obtain experimental verification of the theory, measurements were made on a zinc plate, for which the following values were found: $\mu = 0{\cdot}188 \pm 0{\cdot}009$ (from the ratio of the frequencies of the first overtone and the fundamental), $E = 11{,}010 \times 10^8$ dynes/cm.^{2} (from the fundamental) or $10{,}970 \times 10^8$ (from the first overtone). J. W. T. W.

800. *Change in Elasticity of a Mild-steel Wire with Current and External Heating.* **H. L. Dodge.** (Phys. Rev. 5. pp. 373–384, May, 1915.)—Forms a continuation of previous work on the effect of heating (both internal and external) on Young's modulus [see Abs. 376 (1914)], the same apparatus being employed with but few alterations. The same conclusions are arrived at as

for the copper wire tested previously, no hysteresis being observed nor, indeed, any history effect except a small gradual increase in the modulus with continual stretching and heating of the wire. Contrary to the observations of Walker [Abs. 1986 (1907)], heating by an electric current is found to have no other effect than that caused by the accompanying temperature-change. The modulus of the wire decreases with the rise of temperature at an increasing rate, this decrease being slow and almost uniform up to about 300° C., but then becoming more and more rapid, as indicated by the results exhibited in the following table:—

Temperature.	Modulus × 10^{-11} Dynes/cm^2.	$\frac{dE \times 10^{-11}}{dT}$	Total Decrease, Per Cent. of E at 20° C.	Temperature.	Modulus × 10^{-11} Dynes/cm.^{2}.	$\frac{dE \times 10^{-11}}{dT}$	Total Decrease, Per Cent. of E at 20° C.
20° C.	19·3	0·0035	0·0	300° C.	18·0	0·0074	6·7
50	19·2	0·0036	0·5	350	17·5	0·0106	9·3
100	19·0	0·0038	1·5	400	16·8	0·0205	11·9
150	18·8	0·0041	2·6	425	16·1	0·0310	16·5
200	18·6	0·0047	3·6	450	15·1	0·0470	21·7
250	18·3	0·0058	5·2	475	13·8	0·0860	28·5

J. W. T. W.

801. *Torsional Oscillations of Iron Wires in Magnetic Fields.* **W. Brown.** (Roy. Dublin Soc., Proc. 14. 32. pp. 393–404, March, 1915.)—An account is given of experiments on the subsidence of torsional oscillations of iron wires and alloys when subjected to the influence of alternating magnetic fields of frequency 50 per sec. A pure iron wire was examined in a hard and soft condition, and from the values given in the table of results it appears that for the hard wire the amplitude of the 70th vibration is diminished for the increased load in both the d.c. and the a.c. magnetic field, whereas for the soft wire the amplitude of the 70th vibration is decreased in the d.c. field and increased in the a.c. field for increased load. For iron wires both in the hard and soft states the damping curves, or curves showing the subsidence of torsional oscillations obtained with the alternating magnetic fields, all lie below the curves obtained with the direct longitudinal magnetic fields; whereas in alternating magnetic fields the curves got with hard Ni-wire lie below, and those obtained with soft Ni-wire above, the corresponding curves got with direct longitudinal magnetic fields. The results of tests on Stalloy are also given. There was much less damping of torsional oscillations in the Stalloy than in a wire of Swedish charcoal iron. J. J. S.

802. *Behaviour of Riveted Joints under Stress.* **J. E. Howard.** (Power, 41. p. 216, Feb. 9, 1915. Paper read before the [Amer.] Soc. of Naval Architects and Marine Engin.)—The most important feature about a riveted joint, namely, its elastic behaviour, is generally ignored. Few riveted structures are free from local overstrains, which, however, do not necessarily endanger the joint. For low loads the degree of rigidity of a multiple-riveted, double butt strap joint may be at least equal to that of the solid plate, but at higher loads a considerable divergence becomes apparent. When frictional resistance contributes to the initial rigidity of the joint it is doubtful if the laboratory test gives any idea of the behaviour in service, since vibratory stresses and changes in temperature may give rise to a creepwake of a surface moving through air. Qualitative conclusions are drawn, however, and the effect of camber is compared for various planes, when the results obtained appear to agree with those found experimentally. An excellent description of the functions and transformations employed in the theory of discontinuous motion is also given. H. H. Ho.

809. *A Tidal Problem.* **H. Lamb** and **[Miss] L. Swain.** (Phil. Mag. 29. pp. 737–744, June, 1915.)—The object of this paper is to illustrate the theory of tides in a very simple case, namely, that of an equatorial canal of finite length, the tide-generating body being supposed to revolve uniformly in the plane of the equator. The problem is almost the only one which can be used to exemplify a point of some importance in tidal theory. On Laplace's dynamical as on the equilibrium theory there is exact agreement (or exact opposition) of phase between the tidal elevation and the forces generating it, in the case of an ocean covering the globe or bounded by parallels of latitude, the depth being supposed either uniform or a function of latitude only. Observed conspicuous and varied differences were explained by Newton as due to water inertia combined with the irregular configuration of the actual oceans, while Airy attributes them mainly to friction. Qualitatively Airy's explanation holds as it is merely a particular case of the theory of forced oscillations with damping, but there is still the question of the sufficiency of frictional forces to account for the observed differences. The Helmholtz conclusion that viscosity has an insignificant influence on large-scale motions of the atmosphere has been extended to tidal oscillations of water by Hough, who found that the damping of free oscillations of the ocean of the semidiurnal type would hardly be sensible until after the lapse of a considerable number of periods. It follows from this that the phase-differences produced by friction in an endless equatorial canal would be insignificant, and therefore the influence of friction on ordinary tidal phenomena unimportant. It follows also that phase-differences must arise in another way, from the causes indicated by Newton, in limited canals or oceans, and a mere equilibrium theory, when corrected on the principles explained by Thomson and Tait, will give differences of phase. For instance, in the case of a canal a few degrees in length lying along the equator, when the moon (or antimoon) is in the zenith the differential changes of level are everywhere slight, since the disturbing force is nearly vertical and uniform. When the moon is on the horizon the changes are again slight, since moon and antimoon now nearly counteract one another as regards the horizontal force. Hence at the ends of the canal there will be high or low water for some intermediate position, and theory shows the corresponding hour-angle to be 45°. At the centre the range is comparatively small, and high water coincides with the moon's (or antimoon's) transit. Calculations are given in the paper to illustrate this point of view, and are accompanied by graphical interpretation. H. H. Ho.

810. *Relativity Dynamics.* **J. Ishiwara.** (Tôhoku Univ., Sci. Reports, 3. pp. 321–335, Dec., 1914.)—A mathematical discussion by four-dimensional vector analysis of the relativity principle applied to dynamics and thermodynamics. [See Abs. 1480 (1907).] E. H. B.

811. *Pear-shaped Equilibrium Figure of a Fluid Mass.* **P. Humbert.** (Comptes Rendus, 160. pp. 509–510, April 19, 1915.)—Discusses the numerical values of the constants occurring in the mathematical treatment of the problem. [See next Abs.] E. H. B.

812. *Figure of Equilibrium in Rotating Fluids.* **P. Humbert.** (Comptes Rendus, 160. pp. 594–596, May 3, 1915.)—In the series of figures of equilibrium approximating to the ellipsoids of Jacobi, that which occurs after the pear-shaped figure corresponds to the value $n = 4$ of the parameter of Lamé's equation, and presents three planes of symmetry. Poincaré has given a scheme for this figure, which, like that for the pear-shaped figure, is not based on calculation. Liapounoff has also dealt with this figure, but has drawn no conclusion relative to its form. The study of this form is the object of the present paper. It is found that the scheme of Poincaré is not far from being correct. [See preceding Abs.] A. W.

813. *Fall of Drops from Capillary Orifices.* **P. Vaillant.** (Comptes Rendus, 160. pp. 596–598, May 3, 1915.)—The author has previously shown [Abs. 1209 (1914)] that the weight of the drops which fall from a capillary orifice is a complex function of the frequency of fall. As this frequency is increased the weight at first increases, attains a max. value, and then decreases very rapidly, but undergoes, for certain critical values of the frequency, sudden augmentations, so that at great velocities the weight of the drop may be considerably greater than that corresponding to the first maximum. By comparing the results obtained with a series of 15 tubes of various internal and external diameters, the author has been able to show that the laws governing the phenomenon are quite definite and relatively simple. The experimental arrangement was the same as in the earlier work, but was improved in some respects. The principal results obtained were as follows :—(i) The product of the internal diam. d and the interval of fall T corresponding to the first maximum is a constant number A or a simple multiple of this number. From zero frequency up to that corresponding to the first maximum, the weight varies almost linearly with the frequency. The straight-line graph defines by extrapolation the weight P_∞ corresponding to zero frequency. (ii) The quotient by the internal diam. d of the increase of weight $\delta(= P_m - P_\infty)$ of the drop from the origin up to the first maximum is a constant number B, or a simple multiple of B. (iii) The quotient of the weight P_∞ at the origin by the external diam. D is a constant number C. This constant is, moreover, different from B, and is not the same for tubes of external diam. greater than 5 mm. as for tubes of diam. smaller than this. (iv) When a sudden increase of the weight of the drop occurs, the quotient of this increase by the internal diam. is equal to B or to a simple multiple of B. A. W.

814. *Age of the Earth.* **F. A. Lindemann.** (Nature, 95. pp. 203–204, April 22, 1915.)—The present communication deals with the general impression that Kelvin's estimate, that the temperature of the earth could not have been anything like its present value for more than 20–30 million years, has been superseded, and that the discoveries in radio-activity allow us to assume a period of the order of thousands of millions of years. The radiation from the earth just compensates the amount received from the sun, so that the sun's temperature determines the earth's. The possibility of the latter being maintained by radio-active processes before the sun was incandescent, and that the radio-active substances have died off subsequently, need scarcely be discussed seriously, since, apart from the sterilising effects of the rays, any radio-active substances with a sufficiently long life to keep up the temperature of the earth for any considerable length of time would not disappear quickly. The author concludes that the duration of the present

state cannot have exceeded the time, namely about 30 million years, since which the effective temperature of the sun has been about 6000°, its present value. To explain a greater age other sources of energy must be found, for neither the heat of chemical combination, nor any possible increase in the specific heat, are large enough. It has been suggested that at the enormous pressure and temperature inside the sun radio-active processes might be modified, and even that ordinary elements might break up. Now the energy of a reaction for radio-active change is of the order 10^{-5} erg per molecule, and even at 500 million degrees only one atom amongst 10^{40} would be moving fast enough to influence a reaction which liberates 10^{-5} erg. As this temperature is beyond the bounds of possibility in any part of the sun, the conclusion must be drawn that any process which liberates anything like the requisite energy is unaffected by solar conditions and takes place at the same rate on the sun as on the earth. Ordinary radio-active materials must next be considered, and here a gain of only 5 million years would be obtained even though the whole sun were composed of uranium. An explanation could be given by the assumption of the sun being created some 10^9 or 10^{10} years ago out of special radio-active material which produces an enormous amount of energy, and that it has been breaking up ever since. As this material is non-existent on the earth, the latter would have to be the object of a special creation. This hypothesis, however, is beyond discussion. The above assumption is unnecessary for explaining the existence of uranium, as it is quite conceivable that a certain amount of radio-active matter might be produced afresh during every stellar collision. The energy of substances formed in this way would not be available to explain a greater amount of energy on the sun, as their energy is abstracted from the gravitational energy, and has already been taken into account. H. H. Ho.

815. *Detection of Seismic Zones by Means of Barometric Gradient.* **A. Nakamura.** (Math. Phys. Soc., Tōkyō, Proc. 8. pp. 69–72, March–April, 1915.)—The barometric gradient as a secondary cause of earthquake has already been discussed by Terada [Abs. 778 (1909)] and by Hasegawa. The latter has shown that the barometric gradient in Gihu district at the epoch when an earthquake in that district occurs, is generally perpendicular to the dislocation line of the Mino-Owari earthquake in 1891. Nagaoka suggested that if such is the case in general, a clue may be found for detecting the direction of some unknown seismic zones or dislocation lines. The method, if feasible, will probably be more accurate than to construct the zones statistically by locating a large number of epicentres. The present author, to test the general applicability of the method, has taken 50 earthquakes, all weak or slight, observed in Tukuba during 1904. Hasegawa's method was adopted of taking the barometric pressure just at the moment of the earthquake by graphical interpolation from 4 observations, while the gradients were given by Okada's process. Tables are given, and the result is found that the direction of the prevailing gradient at the epoch of earthquakes is nearly perpendicular to the seismic zone found by Omari from statistical grouping of epicentres. This confirms Hasegawa's results and realises Nagaoka's suggestion. H. H. Ho.

816. *Nature of Hawaian Earthquakes.* **H. O. Wood.** (Bull. Seis. Soc. of America, 4. pp. 169–208, 1914. Nature, 95. p. 215, April 22, 1915. Abstract.) —The author has collected evidence tending to show that the great Hawaian earthquakes of 1868 should be regarded as being of tectonic, rather than of

true volcanic origin. The most violent disturbance of the series, that of April 2, was preceded and followed by numerous accessory shocks, disturbing an area of some 375,000 sq. miles. Its depth of origin must have been considerable, and it gave out seismic sea-waves, thus showing difference from the truly volcanic seism. C. P. B.

817. *Rotation of the Earth.* **H. Glauert.** (Roy. Astron. Soc., M.N. 75. pp. 489–495, April, 1915.)—Various investigators have detected similarities in the deviations in longitude of the moon, Mercury, and the sun from the theoretical values, and it has been suggested that this general effect may be in whole or part due to some disturbance of the earth's rotation period, thus altering the unit of time, and correspondingly changing the apparent position of any body moving fast enough to show the effect. In the present paper the author specially examines the errors in longitude of Mercury, Venus, and the sun for evidence of this kind. He concludes that these errors may be accounted for by a rather irregular variation in the rate of rotation of the earth, the change of momentum being partially or entirely compensated for by a corresponding change in the mean motion of the moon. C. P. B.

818. *Spurious Magnetic Disturbances attending Earthquakes.* **H. F. Reid.** (Bull. Seis. Soc. of America, 4. pp. 204–214, 1914. Nature, 95. p. 215, April 22, 1915. Abstract.)—Numerous observations have been made of the oscillations of magnetic needles during the passage of earthquakes, but it is shown that there are certain periods of horizontal and vertical disturbances which will cause marked oscillations of unifilar and bifilar magnetic balances. It is thus possible that many of the interferences with the magnetic records by earthquakes may be due to purely mechanical vibrations, and are not indicative of the action of magnetic forces or electric currents. C. P. B.

819. *Photographs of the Milky Way and of Comets.* **E. E. Barnard.** (Lick Observatory, Publ. 11. pp. 9–46, 1913.)—This volume consists mainly of 128 plates of collotype reproductions of photographs taken by the author with the Willard lens during the period 1892–1895, supplemented by brief descriptions of the visual observations. The objects dealt with comprise the nebulous regions of Scorpio and Ophiuchus, the nebula of ν Scorpio and of ρ Ophiuchi; and the following comets: Comet I 1892 (Swift); III 1892 (Holmes); IV 1893 (Brooks); II 1894 (Gale). L. H. W.

820. *Sun-spot and Solar Corona of* 1914 *August* 21. **A. L. Cortie.** (Roy Astron. Soc., M.N. 75. pp. 496–501, April, 1915.)—An attempt is made to trace any possible connection between certain streamers of the corona of 1914 Aug. 21, and the large sun-spot then on the solar disc. This spot was apparently not an isolated disturbance, as reference to past records showed that it was one of a series of disturbances in the same locality on the sun's surface. The corona was in general of the minimum type, but with several bright streamers superposed on the equatorial wings. In the NE. quadrant there was a remarkably bright sheaf of rays, and in the NW. quadrant a curved streamer with two prominent tips or horns. As the spot was some 68° from the sun's limb, a geometrical application of Pascal's theorem was made to determine whether the coronal streamers would, when produced inside the solar limb, intersect in the region of the spot. There seems to be evidence that five of the streamers do project back into the spot region, and this gives support to the view that this disturbed region was the seat of the emanation of widely divergent streamers. C. P. B.

821. *Secular Acceleration of Moon's Mean Motion.* **J. K. Fotheringham** and **G. Longbottom.** (Roy. Astron. Soc., M.N. 75. pp. 377–394, March, 1915.)—Numerous attempts have been made to determine the acceleration of the moon's mean motion by means of ancient eclipses of the sun and moon, but no record appears of the use of the ancient observations of occultations for this purpose. The authors propose to investigate the occultation records in the Almagest, so that the motion of the moon may be directly compared with the stars. The value found is + 10·6″ per century, which is in close agreement with that of + 10·9″ found by Cowell from the study of ancient solar eclipses. C. P. B.

822. *Measures of Astrographic Plates from Vatican Observatory.* **E. F. Bellamy.** (Roy. Astron. Soc., M.N. 75. pp. 425–428, March, 1915.)—Two plates of the Vatican series for the Astrographic Catalogue were accidentally exposed on the same region, and as these were separated by an interval of 14 years (1899–1913) they were specially reduced with the object of detecting any proper motion. The result does not give any evidence of motion of appreciable amount. C. P. B.

823. *Errors of Measurements on Astrophotographic Plates.* **W. Gibson.** (Roy. Astron. Soc., M.N. 75. pp. 483–489, April, 1915.)—Discussing the errors of measurements made on astrographic photographs, the author takes the results of three observers' measures of the same 10 star images on a plate. Each star image was measured 7 times by each observer in 4 orientations of the plate, bisection being made twice for each measure. The results suggest a definite dependence of the personal error on the orientation in which the readings were taken. In many cases it seems true that adjacent rather than opposite orientations give the best correction, but for purposes of great accuracy it seems advisable to take readings in all four orientations. C. P. B.

824. *Comparison of Magnitude Scales of Astrographic Catalogue.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 75. pp. 465–483, April, 1915.)—The present note is in continuation of previous papers [Abs. 278, 423 (1915)], and deals with the Oxford magnitudes. The main point is to draw attention to the excess or defect of faint stars in different parts of the zones. From the tables compiled there is shown a systematic diminution of faint stars in certain parts of the sky, and in order to collect further evidence on the point, the results given by other astrographic catalogues, Algiers, Cape, Perth, etc., are examined in similar manner. A diagram is given showing the regions in which this veiling appears to take place, in relation to the galaxy and equator. C. P. B.

825. *New Method for Determining Constant of Aberration.* **W. de Sitter.** (Roy. Astron. Soc., M.N. 75. pp. 458–464, April, 1915.)—Four stars are selected in the equator at intervals of 6 hours, and with one coming to the meridian at midnight. Then it is seen that aberration enters into the difference of the arcs west and east from the meridian star to the stars east and west, and the accuracy of the observation will depend on the measurement of the difference of two nearly equal arcs, which are measured on the same night with a few hours' interval. The question as to how far refraction may nullify the value of the method is examined carefully, the conclusion being that with a suitably devised programme the uncertainty in the determined value of the aberration constant due to refraction would be ± 0·003″. This is by the measurement of right ascensions, for which it is proposed to utilise something like the device suggested by Turner, or by the new comparator proposed by Bigourdan. The refraction may be eliminated altogether by observing azimuths instead of right ascensions, but this involves complications in equipment which might lead to lessened stability. A comparison is made with the method proposed by Loewy in 1887, which involved a moving equatorial, and in which parallax was not eliminated. C. P. B.

826. *Satellites of Uranus.* **R. G. Aitken.** (Lick Observatory, Bull. 8. [No. 269] pp. 142–148, 1915.)—Details are given of measurements of the satellites of Uranus, made with a power of 350 on the 36-in. refractor at the Lick Observatory. Titania was chosen as the reference point for the position of the other three satellites. C. P. B.

827. *Dynamics of a Globular Stellar System.* **A. S. Eddington.** (Roy. Astron. Soc., M.N. 75. pp. 366–376, March, 1915.)—In a former paper [Abs. 630 (1914)] reasons were given for believing that the stars move in undisturbed paths under the general attraction of the whole stellar system without experiencing any appreciable deflection by the chance encounters or approaches of other stars. This enables the "free path" of a star to be regarded as infinitely great. In the present paper an investigation has been made of the dynamics of a stellar system satisfying the conditions of stability, and with distribution of stellar velocities approximating to those actually observed. From the analytical discussion presented, it is found that the hypothesis of an ellipsoidal distribution of velocities, together with the assumption of globular symmetry, serves to determine uniquely the density and state of motion throughout the whole system. Neglecting the possibility of systems with a hollow centre, we find that there is one singular solution with the density infinite at the centre, but that in general the central density is finite and not excessively greater than that near the sun. The central density cannot, however, be less than 4 times that near the sun.

The prolateness of the velocity-ellipsoid must increase with increasing distance from the centre. The major axis remains constant, and the minor axis continually decreases outwards. C. P. B.

828. *Catathermic Rays.* **A. Le Bel.** (Comptes Rendus, 160. pp. 336–338, March 15, 1915.)—A long discussion is given of the possible transformations of energy in celestial space, led up to by a theory propounded by Tissot, who supposed that the heat lost by the stars was transformed in space into a special radiation, susceptible of returning to the stars and restoring their energy. In the endeavour to detect this special radiation, the author presents his idea of what he calls catathermic rays, which are said to be produced in the interior of a body when heated under special conditions. [See Abs. 1693 (1913).] C. P. B.

829. *Stellar Classification.* **N. Lockyer.** (Nature, 94. pp. 282–284, Nov. 12, 1914; 618–619, Feb. 4, and pp. 644–645, Feb. 11, 1915.)—In a series of notes it is sought to examine whether a combination of the meteoritic hypothesis and the Kensington classification of stars into series of ascending and descending temperatures could furnish any information regarding the physical differences of the stars. By correlating the Kensington and Harvard classifications, and taking note of coincidences in known cases, it is now found possible to classify 900 more stars, from the Harvard records, on the Kensington system. C. P. B.

LIGHT.

830. *Rapid Testing of Small Portable Telescopes. Description of a Universal Test Chart.* **G. Bigourdan.** (Comptes Rendus, 160. pp. 18–21, Jan. 4, 1915.)—The usual methods of testing the object-glasses of small telescopes, sextants, theodolites, etc., are merely comparative, and the test types frequently employed are difficult to reproduce identically, owing to difference in detail in printed characters in use in different places. The author therefore suggests for universal adoption a form of test chart easy to copy, which will enable observations to be referred to one fixed standard. The new chart contains 25 groups (5 rows of 5) of black parallel lines on a white background, each group being contained in a square of 10 mm. side. The black lines and white spaces in each single square are of equal width, the width increasing regularly from square to square. By each square is printed a number expressing, in seconds of arc, the angle subtended by the sum of the breadths of one line and space, when the chart is placed at 10 m. distance. For the first group, which contains 20 lines, this angle is 10″, and the angle increases 2″ for each group, which contains only 4 broad lines. If it is desired to find the resolving power of an objective mounted in a telescope on a fixed stand, let the chart be placed at a convenient distance d; then the angle subtended by the sum d the widths of a line and space in a square whose number is n will be $10n/d$ secs. On then examining with the telescope different squares on the shaft, bringing each to the centre of the field, the broader lines will be distinctly separated. Squares containing fine lines will appear of a uniform grey tint, and there will be an intermediary group in which the divisions are at the limit of visibility, and which will correspond to the resolving power of the telescope. Foucault's experiments, confirmed by C. Wolf and André, have shown that the resolving power is proportional to the aperture of the objective; and is 1″ for an aperture of 0·13 m. The ratio of the theoretical aperture to the actual aperture required to obtain the same degree of resolution is the measure of the performance of the objective. The tests may be repeated with the aid of a diaphragm, and comparison of results will show whether the defect lies mainly in the outer zone of the objective. Astigmatism, either of the instrument or the eye, may be tested for by employing two or more test charts with their lines in different directions. Numerical expressions for the extent of the field, and of the relative values of its different parts, may be obtained by using several charts distributed at regular intervals, say of half a degree, and finding the resolving power for each. A. E.

831. *Determination of Thickness of Rock-slices by Means of Interference-figure of Component Minerals.* **M. Kawamura.** (Kyushu Univ. Coll. of Engin., Mem. 1. No. 1. pp. 1–29, 1918.)—An account is given of an interference-figure method of determining the thickness of rock-slices used for microscopical investigations. The method is not claimed to be much more accurate than the usual interference-colour method, but it can be used with greater facility since such sections as are required occur in rock-slices more frequently than in the other mode.

Reference must be made to the original for details. L. H. W.

832. *Theory of the Rayleigh-Zeiss Interferometer.* **L. H. Adams.** (Washington Acad. Sci., J. 5. pp. 265–276, April 19, 1915.)—In the course of work in which a Zeiss interferometer was employed as a means of determining the concentration of the equilibrium solutions [Abs. 788 (1915)] some trouble was experienced at first in obtaining concordant readings. This was found to be due to an alteration of the achromatic reference fringes produced by differences in optical dispersion. The author has now undertaken the investigation of the relationships in order to derive formulæ from which the exact amount of shift of the achromatic fringe could be predicted. The investigation, which is mathematical in character, cannot be suitably abstracted.

A. F.

833. *Sensitive Method for Examining Optical Qualities of Glass Plates.* **Berkeley** and **D. E. Thomas.** (Phil. Mag. 29. pp. 613–617, April, 1915.)—This paper describes the use of a Rayleigh interferometer for testing a glass plate. The upper part of the two beams giving the interference pattern is displaced slightly downwards, just before entering the observing telescope, by means of a glass plate, so that the fringe system is separated into two halves by a sharp horizontal line, the upper half being used as a set of reference marks. The plate under test is placed in the path of the light at an angle of 45°, and the upper and lower bands are brought into coincidence by rotating a glass plate in the lower half of the beam by means of a micrometer screw. The test plate is then rotated through 180°, the two beams still passing through the same parts of the plate, and coincidence again effected. The difference between the two screw readings is a measure of the difference in the optical paths in the two positions. The retardation of one beam behind the other can be measured to 1/100th of the wavelength of the light used. The difference in the paths found is $D(\mu-1)$, where D is the thickness of the plate. The variation may be either in D or in μ, but it is pointed out that the condition for a perfect echelon spectroscope plate is that $D(\mu-1) =$ a constant. Michelson's method, which is usually used for testing such plates, only gives information about the product $D\mu$. Also the method used here is 30 % more sensitive, and it is shown how the sensitiveness may be still further increased. Suggestions are made as to the practical applications of the method for the construction of echelon plates.

T. H.

834. *Temperature Refraction Coefficients of Optical Glass.* **J. W. Gifford.** (Roy. Soc., Proc. 91. pp. 319–321, May 3, 1915.)—In a previous paper [Abs. 51 (1913)] the refractive indices of a number of samples of glass were given. The temperature coefficients are now given together with the refractive indices of some glass meltings since measured.

T. H.

835. *Air Transparency for Infra-red Rays.* **G. Michaud** and **J. F. Tristan.** (Scientif. Amer. 115. pp. 521 and 531, Dec. 26, 1914.)—Alizarin blue S, used in conjunction with nitrate of silver, makes a sensitiser for photographic plates which not only carries the sensitiveness far down into the infra-red, but shortens the exposures with yellow screen. Remarkable photographs of mountain ranges, taken by infra-red light on plates so sensitised, are given.

A. D.

836. *Selective Absorption.* **A. J. Bull** and **A. C. Jolley.** (Phot. J. 55. pp. 134–140, April, 1915.)—A high transmission of one part of the spectrum is accompanied by a complete absorption in another region only when the

wave-lengths of the region absorbed are shorter than those transmitted. This suggests that the search for ideal printing inks may prove fruitless. Transmission curves and reflection curves are given for various salts, filters, and inks, including the filters first used by Clerk Maxwell in 1867. A. D.

837. *Infra-red Transmission and Reflection of Aniline Dyes.* **J. B. Johnson** and **B. J. Spence.** (Phys. Rev. 5. pp. 349–358, May, 1915.)—The reflection and transmission curves of a number of aniline dyes have been obtained for the infra-red region to the wave-length 12 μ, thus adding more data to the problem of chemical constitution and absorption. In the transmission curves for related compounds a certain similarity is found.

The theory that certain chemical groups in the molecule give rise to definite absorption does not hold with any degree of consistency for these complex substances. L. H. W.

838. *Mechanical Equivalent of Light.* **H. E. Ives, W. W. Coblentz,** and **E. F. Kingsbury.** (Phys. Rev. 5. pp. 269–293, April, 1915.)—In this paper a number of definitions of various light quantities are first given, and in accordance with these the mechanical equivalent of light is defined as the value of the lumen in watts. A description is next given of an experimental determination, by two different methods, of the mechanical equivalent of light, and the mean result obtained is given as 0·00162 watt per lumen. The first of the two methods is based on the mechanical evaluation of a given radiant energy-flux as light, by the use of absorbing media or equivalent means. The second method consists in the measurement of a selected monochromatic radiation, of known luminous efficiency, as light and power. The latter method has some advantages; for instance, the value obtained for the luminous equivalent of the monochromatic radiation has an independent value in that it can be used with any luminosity curve, not only the one selected by the experimenter. If the monochromatic radiation is selected near the maximum of visual sensibility the resultant value is largely independent of errors in the determination of the ends of the luminosity curve, since the maximum is fairly well agreed upon. The great difficulty in the determination by this method is the measurement of the coloured light, for which special methods are necessary. Luminous flux, on the basis of the definitions given, can be measured in c.g.s. units, or in watts, and consequently the watt is a rational standard of luminous flux ("primary standard of light"). The measurement of luminous flux in watts and the establishment of the watt as the standard are dependent on the evaluation of the present standard and units in terms of the watt. The mechanical equivalent of light is, therefore, the most fundamental quantity in the establishment of light-measurement on a physical basis. A. W.

839. *Luminous Sources with Reduced Surface.* **Dussaud.** (Comptes Rendus, 160. pp. 394–395, March 29, 1915.)—A continuation of previous work [Abs. 1135 (1913)]. With new cooling arrangements the emission from the sources dealt with was much increased, the source being brought considerably nearer to the optical system; the loss due to obliquity of the rays was compensated by the use of additional lenses. The sources employed were glow-lamps with solenoidal tungsten filaments, the spirals being very close together, and the bulb being filled with an inert gas. Their intensity varied from 32 to 4000 c.p., and the surface of the latter did not reach 4 cm.^{2}. Without excess voltage these sources are, with the author's optical system,

quite sufficient for all classes of projection work. With excess voltage they can be made to yield about 10 times the light on ordinary voltage, but the life of the lamp is thereby much reduced. A. W.

840. *Distribution of Energy in the Radiation from the Uviol-glass Lamp.* **A. J. Allmand.** (Chem. Soc., J. 107. pp. 682–688, May, 1915.)—A number of photo-chemical investigations have been carried out in which the Schott mercury uviol-glass lamp is used as the source of radiation. In order to utilise fully the results of these investigations, a knowledge of the distribution of energy in the different parts of the spectrum of the lamp is necessary. Measurements have been made by Winther [Abs. 59 (1914)], and his results indicate, as would be expected, that the intensities of the ultra-violet bands, compared with the blue band, are far less than for the quartz lamp, and also that the relative intensity of the violet band 405 μμ is considerably less. The author has investigated the radiation from the uviol-glass lamp, using the method employed by Ladenberg for the quartz lamp, namely, direct measurement of the intensity of the different bands by means of a thermopile. The lamp was run off the 230-volt mains in series with a resistance and an inductance. It usually took about an hour to attain constant values of current and voltage. Measurements were made with (*a*) 3·5 amps. and 56 volts, (*b*) 3·2 amps. and 84 volts, and practically identical values for the intensity ratios were obtained. Column 1 of the following table contains the values finally obtained, referred to the intensity of the blue band as unity. Columns 2 and 3 contain respectively Winther's figures for the uviol lamp, and Ladenburg's figures for the quartz lamp:—

λ.	Uviol (A).	Uviol (W).	Quartz (L).
571 μμ	0·27	—	2·63
541	0·73	—	3·93
436	1·00	1·00	1·00
406	0·56	0·29	0·54
362	0·42	0·25	1·83
313	0·17	0·045	1·28 (0·86)

It remains to apply, if possible, the above figures to already existing photo-chemical data obtained with the uviol lamp. This can only be done approximately, and with a great deal of uncertainty. In an investigation of the photo-chemical oxidation of quinine by chromic acid, Luther and Forbes, assuming complete absorption of the 406 μμ and 362 μμ bands, found the ratios $k_{406}/k_{362} = 1{\cdot}00/0{\cdot}82$. The figures obtained in the present paper indicate $i_{406}/i_{362} = 1{\cdot}00/0{\cdot}75$. A. W.

841. *Luminous Efficiencies and Equivalents of Radiant Energy.* **A. Amerio.** (N. Cimento, 8. pp. 440–460, Dec., 1914.)—Determinations by different investigators of the mechanical equivalent of light have given discordant results, owing principally to the indefinite character of the unit of light and to the complicated manner in which the eye functions, the distribution of the sensitiveness of the eye between the different colours depending on the photometric method employed, the intensity of the illumination and the condition of the eye itself. If the illuminations are maintained sufficiently, but not excessively, intense, four series of equivalents may be distinguished—namely: that of monochromatic light as a function of the wave-length (1) for equal brightnesses and (2) for equal visual acuities, and that of white light as

a function of the temperature, (3) for equal brightnesses and (4) for equal visual acuities. Each of these separate cases is considered [see Abs. 206 (1915)]. For the number of candles corresponding with 1 watt of light, the expression "luminous equivalent of radiant energy" is suggested. In discussing luminous efficiency, the term "elementary efficiency" is used to denote the amount of energy radiated over an infinitesimal but constant interval, $d\lambda$, divided by the total quantity radiated σT^4, and it is shown that: (1) at the maxima of the spectrum the elementary efficiency is proportional directly to the absolute temperature and inversely to the wave-length, and (2) the amount of energy radiated by a black body between $\lambda = 0$ and the maximum of the spectrum is $\frac{1}{4}$ of the total energy, irrespective of the temperature. About 12 Hefner units per watt would be radiated by a black body transforming the whole of the energy absorbed into radiant energy; this max. effect would occur at about 7000°, which is approximately the temperature of the solar photosphere. T. H. P.

842. *Brightness of Intermittent Illumination.* **M. O. Saltmarsh.** (Phil. Mag. 29. pp. 646–650, May, 1915.)—When a surface receives intermittent illumination a flicker will result unless the speed is sufficient for the eye to retain the sensation of brightness during the period over which the light is cut off. The author inquires whether the brightness in these circumstances is affected by overlapping of the previous situation. He describes a series of experiments with discs interposed between the source and the photometer, having sectors of various kinds, by means of which the intervals between brightness and darkness of the photometer screen could be adjusted. The disc was run at such a speed that flicker disappeared, and the resultant illumination was balanced against that from a steady source. It is shown that in every case the diminution in illumination agreed with the calculated loss of light due to the interposition of the sectors. Furthermore, as the speed of the disc is increased the flicker ceases at a certain point and does not reappear when the speed is increased still further. From these results it is concluded that the overlapping of visual impressions makes no difference to the apparent brightness of the disc. J. S. D.

843. *Choice of a Group of Observers for Heterochromatic Measurements.* **H. E. Ives** and **E. F. Kingsbury.** (Am. Illum. Eng. Soc., Trans. 10. pp. 203–208, 1915.)—In making measurements on coloured light with the flicker photometer the visual characteristics of the observers are of the utmost importance. A group of observers should be chosen whose average is that of an average eye. In this paper a method is described, by means of two test-colours, for selecting a group whose average characteristics shall be those of the very large number who determined the photometric scale used by the authors [see Abs. 813B (1915)]. The test-colours recommended are given by the following aqueous solutions:—(i) Yellow solution: potassium dichromate—72 gm. to 1 litre of solution. (ii) Blue-green solution: copper sulphate—58 gm. to 1 litre of solution. This paper, together with those which have preceded it, give full descriptions of instruments and methods by which uniform results may be obtained in different laboratories in the photometry of coloured lights. A luminosity scale has been developed, to which these uniform results are referred. The test-colours described may be compared to the fixed points by which a thermometer is calibrated. A. W.

844. *Mutual Influence of Resonators exposed to Primary Waves.* **Rayleigh.** (Phil. Mag. 29. 209–222, Feb., 1915.)—This paper is intended

as the first step in a preliminary mathematical inquiry which the author hopes may lead to an approach to the consideration of absorption, viz. the conversion of radiant into thermal energy. The first case treated is a simple ideal point aerial resonator vibrating symmetrically, although the type being inadmissible for transverse vibrations, the result cannot be regarded as even roughly applicable to radiation. The sole condition given then is that no work is to be done at the resonator, and this leads to a relation which must hold at a resonator tuned to respond to primary waves when isolated from other influence. A series of resonators on the same primary wave-point, and similarly placed relatively to each other, is next dealt with, the resonators tuned to give (1) the maximum individual response to the primary waves; (2) the maximum aggregate response. It is suggested that further examination may show that the result obtained, a nearly total specular reflection, would ensue in the case of a few resonators to the wave-length, and when these are in motion, as in the case of gas molecules. The free vibration is then determined of a single resonator considered as bounded at the surface of a small sphere, the connection being determined between the motion of this surface and the aerial pressure operative upon it as the result of vibration. Finally, the mutual action of two similar resonators is investigated. G. W. de T.

845. *Scattering and Regular Reflection of Light by Gas Molecules.* I. **C. V. Burton.** (Phil. Mag. 29. pp. 625–636, May, 1915.)—A mathematical discussion of vibrators which scatter, without absorbing, wave-energy of definite frequency, though its extension to molecules which absorb some part of the incident energy should present no difficulty. R. W. Wood has lately emphasised the importance of determining experimentally to which category the resonant atoms of mercury-vapour belong, and in the second part some suggestions are to be made towards that end. [See preceding Abs.] E. H. B.

846. *Further Extension of Spectrum.* **T. Lyman.** (National Acad. Sci., Proc. 1. No. 6, June, 1915. Chem. News, 112. pp. 29–30, July 16, 1915. Nature, 95. p. 343, May 27, 1915.)—The author has previously given an account of an extension of the ultra-violet limit of the spectrum to the neighbourhood of wave-length 900 Å. units [Abs. 1244 (1914)]. He has now succeeded in carrying his observations to wave-length 600. The result is chiefly due to the use of helium of considerable purity in the spectroscope and discharge tube. The apparatus used was the same grating vacuum instrument employed in the earlier work, but perfected in such a way as to make it more nearly air-tight than ever before. The spectrum which is obtained with a disruptive discharge in He contains, between wave-length 1250 and 600, upwards of 15 lines, some of them of considerable strength. Experiments with hydrogen have confirmed the existence of the series predicted by Ritz with members at 1216, 1026, and 972. But, owing to the great difficulty of obtaining the gas-content of the spectroscope absolutely free from impurities, the author has not yet been able to identify positively the source of certain strong lines which occupy the positions demanded by the analogue of the Pickering series, and which occur both when hydrogen and when helium is employed. A. W.

847. *Method of Determining the Radiant Luminous Efficiency of a Light Source by Means of a Cell whose Transmission Curve is Identical with that of the Luminosity Curve of the Average Eye.* **E. Karrer.** (Phys. Rev. 5. pp. 189–

211, March, 1915. Abstract of paper before the Am. Phys. Soc., New York, Oct., 1914.)—The author deals somewhat more fully with experiments previously described [Abs. 408B (1915)]. J. S. D.

848. *The Photographic Process.* **C. E. K. Mees.** (Frank. Inst., J. 179. pp. 141–160, Feb., 1915.)—Diffusion of the developer into the gelatine film consists of (*a*) macro-diffusion through the softer channels in the gelatine and (*b*) micro-diffusion through the walls of the harder gelatine cells which enclose the silver halide grains. One nucleus is sufficient to start reduction of all the silver halide present in a granule, if the silver halide can be dissolved and ionised and its silver precipitated; and the loss of one electron per granule by a photoelectric effect is sufficient to account for the latent image, while it is all that the amount of energy in the exciting impact of light will allow. Reversal seems due to a second stage, the actual decomposition of silver halide with liberation of halogen and destruction of some of the latent image produced. This leads on prolonged exposure to visible blackening by the liberation of metallic silver. The effects of the size of grain upon (*a*) sensitiveness, (*b*) gradation, (*c*) colour of the deposit, and (*d*) resolving power are considered. In a low-speed emulsion each of the crystals of halide forming a granule is coated with gelatine, so that each of them must be separately rendered developable by the action of light; whereas in a high-speed emulsion the halide stands distinct from the gelatine and only requires the action of light at one point to render the whole granule developable. Variations in the different sizes of granules and their distribution will lead to modifications in Hurter and Driffield's curves. Goldberg showed (Phot. J., June, 1914) that in resolving power there are two factors: (*a*) the photographic factor, which translates the distribution of light in the emulsion into the distribution of silver after development, this being affected by (*b*) the turbidity factor, which depends on the scattering of light in the emulsion. Nutting now finds that the latter can be broken up into two: (*α*) the turbidity proper of the emulsion and (*β*) its opacity. Thus in the wet collodion plate the turbidity is considerable, but the absorption of blue-violet light is very high, so that the resolving power is good. With the finest granules the turbidity will be negligible; with a diam. a little less than $1\,\mu$ the turbidity is great and the opacity still low, so that the resolving power is poor; as the diam. increases the opacity increases and the resolving power improves until the actual bigness of the granules begins visibly to affect the results. A. D.

849. *Quantitative Absorption Spectra.* I. **F. R. Lankshear.** (Manchester Lit. and Phil. Soc., Mem. 58. No. 15, pp. 1–12, March, 1915.)—The author outlines the experimental methods and apparatus which heretofore have been in general use for the mapping, in a qualitative manner, of the absorption curves of substances in the solution state.

Some few generalisations between absorption and constitution, which have resulted from such methods, are discussed, and the need for quantitative measurements is pointed out, if further advances are to be made along these lines. The quantitative method developed by Henry, which depends on the matching of photographic images obtained by varying times of exposure, is described. This method is based on the Schwarzchild formula $I/I_1 = (t/t_1)^n$, where I is intensity, t exposure, and n a plate number, which is assumed to be accurate for the whole spectrum, any variety of plate and any value of t. This and other assumptions are open to criticism and may produce errors of 30 %.

With the sector apparatus made by Hilger, which is then described, such assumptions are eliminated. In this method each batch of plates is calibrated directly against a piece of glass of known extinction coefficient, and a slight correction is applied to the fundamental Schwarzchild formula. C. S. G.

850. *Radiation from an Electric Source. Line Spectra. Hydrogen Series.* **L. Silberstein.** (Phil. Mag. 29. pp. 709–714, May, 1915.)—Let the source, *i.e.* the seat of impressed electric force, be a sphere, of radius a, having a permittivity K, while that of the surrounding medium is unity. Then the intensity I of electromagnetic radiation emitted by the source is, at distances great in comparison with a, given by $I = f(\lambda, K) \dots$ (1), where λ is the wave-length *in vacuo* and f is a certain function of λ and K (λ). For large values of K, viz. when the refractive index $c/v = \sqrt{K}$ is of the order 10^3, the spectrum (1) of the source consists of an infinite series of very thin and sharp lines, corresponding to the maxima of I, say I_1, I_2, etc., arranged after the descending wave-lengths λ_1, λ_2, etc.; the reciprocals of the latter are the successive roots of a comparatively simple transcendental equation. The requirement that these lines should lie within the visible spectrum reduces the source to molecular dimensions. The intensities of the successive spectrum lines are, with a high degree of approximation, proportional to the square of the wave-length, *i.e.* $I_1 : I_2 : \dots = \lambda_1^2 : \lambda_2^2 : \dots$(2). In other words, the lines, from red to violet, become fainter and fainter. The permittivity of the source may be, in the general treatment of the problem, any function of λ, which function may be said to define the intrinsic or the atomic dispersion. The author assumes $k \equiv 4\pi^2 a^2 K$ to be, in general, of the form—

$$k = a + \sum_{i=1}^{i=k} \frac{\beta_i \lambda^2}{\lambda^2 - \gamma_i^2} \quad \dots\dots\dots\dots\dots\dots(3),$$

where a, β_i, γ_i are constants, which will have to be determined, for each individual spectrum, on the ground of experience, such as the dispersive properties of molar lumps of the substance in question or the characteristic features of the spectrum itself. The present paper deals with certain results in the simplest case of the dispersion law (3), when $k = a + \beta/(1 - \gamma^2/\lambda^2)$. Introducing this value into the full formula (1) it is found that a spectrum is obtained in which the lines become not only fainter but also sharper, and more and more crowded from the red towards the violet end of the spectrum, the lines thus constituting a series having its convergence-point at $\lambda = \gamma$. These being exactly the characteristic features of the so-called first hydrogen spectrum, an attempt was made to determine the constants a, β, γ and the order of magnitude of K, so as to represent this series by the formula obtained. The calculations are not yet completed, but a number of tables are given containing the results of the first attempts. The results of further calculations will be published later. A. W.

851. *Principal Series in the Spectra of the Alkali Metals.* **W. M. Watts.** (Phil. Mag. 29. pp. 775–783, June, 1915.)—The author has analysed the measurements of the various investigators on the absorption, flame, arc and spark spectra of the vapours of the alkali metals. He points out the general applicability of a modified Morgendorff-Hicks formula:

$$\text{O.F.} = \text{C.F.} - 109675/(m + \mu + c/m)^2.$$

By replacing m of the fraction c/m by $(m - 1)$, a better agreement between the observed and calculated values of the lines (principal series) is in general obtained than by using the original formula. This also applies to the Lohuizen form of the equation, where O.F. is substituted for the fraction denominator *m*, and to the Ritz form, where the *m* is replaced by m^2.

In the case of lithium vapour the agreement was hardly so good, but this is probably due to the uncertainty as to the exact value of the convergence-frequency. Tables are given of the different measured series lines, and of the deviations between these and the theoretical values calculated on the basis of the original formula and the three modifications of it. C. S. G.

352. *Effect of Pressure upon Arc Spectra.* **W. G. Duffield.** (Roy. Soc., Phil. Trans. 215. pp. 205–252, 1915.)—A continuation of previous work [Abs. 371 (1911)]. The present paper deals with nickel, in the region from λ3450 to λ5500, and includes an account of the rate of displacement with wave-length; of the relation between pressure and displacement, of the influence of the density of the material and of the intensity of the spectrum lines upon the displacement, and of the resolution of the Ni spectrum into groups of lines. The arc was formed between two poles of the metal (not quite pure) ⅜ in. diam. and about 6 in. long, which were enclosed in a steel cylinder capable of resisting a high internal pressure. The second-order spectrum of the Manchester 21½-ft. Rowland grating spectrograph was used, the dispersion being 1·3 Å. unit per mm.

As in the case of the gold arc, the ease with which the arc burned depended both upon the coolness of the poles and the freshness of the air supply. Of electrodes previously used the Ni arc behaved more like that between Cu poles. The intensity increased very markedly with the pressure, but photometric measurements were again out of the question, owing to the unsteadiness of the arc. At low pressures the Ni arc was distinctly mauve in tint, but it became whiter as the pressure of the surrounding air was increased. In the Ni spectrum some lines broaden nearly symmetrically, but most lines broaden unsymmetrically. Of the latter class by far the larger number are more extended towards the red end of the spectrum, but a few are unmistakably broadened more on the violet side. Under pressure some few of the lines which are sharp at atmospheric pressure retain some of their characteristic hardness of outline at moderate pressures (10 to 20 atmos.), while others lose their sharp appearance altogether and quickly become nebulous. Many that start by being nebulous become more so and disappear.

A critical comparison between the broadening of the lines of various metals will be given in a subsequent paper. Under great pressure the Ag-arc spectrum becomes continuous, and this is due, at any rate in the region investigated, to the broadening of the lines of the first subordinate series. This phenomenon has been looked for in the Ni spectrum, but though there is a certain amount of continuous spectrum on some photographs, it is generally caused by the hot metallic poles rather than by the spreading of the line. There is, however, a very great broadening of some of the lines, λ3566·50 and λ3619·52 being particularly noticeable. The relation between pressure and displacement is approximately a linear one, but the displacements per atmo. are almost invariably greater at low pressures than at high, a fact which seriously challenges the existence of an exact linear relationship. The rate of displacement seems to decrease with increase of pressure.

The rate of increase of the displacement with the wave-length has previously been investigated by the author; the Cu-arc spectrum yielded the result that the displacement was proportional to a power of the wave-length at least as great as the third power and possibly as high as the sixth. The experiments upon the Au arc under pressure favoured a dependence upon the third power of the wave-length. Experiments by Gale and Adams [Abs. 491 (1912)] upon an extended region of the Fe spectrum under a pressure of 9 atmos. support this conclusion, and so do the results of the present research. Tables are given showing how the Ni lines may be resolved into two main groups according to their displacement, and that the first of these is capable of further subdivision. Evidence is given which favours the amount of displacement being dependent in part, at least, upon the amount of material present—a conclusion which is in keeping with that arrived at from the consideration of the variation of the displacement with the intensity of the line. The feature of the lines due to impurities is that they remain fairly compact even at very high pressures, and do not spread out to the same extent or become so foggy as the Ni lines.

A number of photographs are reproduced, and numerous tables are given. **A. W.**

853. *Origin of the "4686" Series.* **T. R. Merton.** (Roy. Soc., Proc. 91. pp. 382–387, June 1, 1915.)—A continuation of previous work [Abs. 552 (1915)]. Photographs were taken with a Fabry and Perot interferometer and a spectrograph in conjunction, and the distance apart of the interferometer plates was varied, giving path-differences (Δ) from 2 to 24 mm. From the series of photographs the limiting order of interference for the lines of hydrogen, helium and the 4686 series could be estimated. Fringes were just visible in the line λ4686 at $\Delta = 4$ mm., and in helium (λ4888) at 24 mm. This gives for the respective orders of interference $N_{4686} = 4/0{\cdot}0004686$ and $N_{He} = 24/0{\cdot}0004888$, and for the mass of the system from which λ4686 originates ($He = 4$) about 0·094, or about $\frac{1}{10}$th of the mass of the hydrogen atom. The author has noticed that in the case of the ordinary He lines the value of N becomes smaller when capacity and a spark-gap are introduced into the discharge circuit, keeping the current through the primary of the coil unaltered. Buisson and Fabry state that under similar conditions broadening occurs in the lines of the Balmer series, but not in the lines of the secondary hydrogen spectrum, and they point out that this would indicate some special cause of broadening for the Balmer series. No mention is made of the pressure in the vacuum tubes at which this observation was made, and at low pressures even a feebly condensed discharge extinguishes the secondary spectrum. Very little is known with regard to the origin of the secondary spectrum, and the broadening of the Balmer series and of the He lines may possibly be explained as being due to the sudden rise of temperature at each impulse, but the above calculation might, by analogy, have no significance if the ordinary He lines corresponded to the secondary hydrogen spectrum. This appears to be unlikely for several reasons. In particular, the solar chromosphere shows the Balmer series and the ordinary He lines very strongly, but contains no trace of the secondary H spectrum. This would indicate that the ordinary He spectrum and the Balmer series are analogous. On the other hand, however, in such experiments as those of King the Balmer series behave as enhanced lines, a supposition apparently negatived by Fowler's demonstration [Abs. 1680 (1914)] that the Rydberg constant of enhanced series is 4N instead of N. In any case the observed broadening with a condensed discharge would by itself appear to limit the use of the method employed to cases in which the radiations are produced simultaneously. It

is possible that the breadth of the enhanced lines may be controlled by circumstances at present unknown, but if the method is valid in such cases, the results would indicate that the 4686 line is due to systems of sub-atomic mass. **A. W.**

854. *Ultra-violet Excitation of the D Line of Sodium.* **R. J. Strutt.** (Nature, 95. pp. 285–286, May 13, 1915.)—The first ultra-violet line of the series whose first member is the Na D line is at wave-length 3303. The question arises as to whether stimulation by light of this wave-length would give rise to D light. Wood has looked for the effect, but without success; Strutt has, however, now obtained satisfactory positive results. The chief essential is a source giving a sharp line of great intensity at λ3303. This was found in a sodium-vapour lamp in quartz analogous to the mercury lamps in general use. Details of the construction and manipulation of these sodium lamps will be published later. The visible light from such a lamp was filtered out by means of a screen consisting of cobalt-blue uviol glass, combined with nitrosodimethylaniline. The light which came through was photographed with a quartz spectrograph, and was found to consist of light of wave-length 3303 exclusively. This radiation was concentrated by means of a quartz lens on a quartz bulb containing some sodium. The bulb was made nearly red-hot with a Bunsen burner, which was then extinguished. A patch of luminosity could be seen on the wall of the bulb when the ultra-violet beam fell upon it. As the bulb cooled and the vapour pressure of the sodium diminished, this patch of light gradually expanded and filled the entire bulb; it then faded away, and had disappeared when the bulb was cold. This behaviour is exactly the same as is seen when D light is excited by the incidence of D light, and although in the present case the light is much fainter, the conditions of observation are in some respects more favourable, for there is no disturbance from visible light scattered or reflected by the walls of the vessel. A sheet of plate-glass 1·2 cm. thick interposed between the source and the bulb completely extinguished the excited light, which must therefore be due to ultra-violet excitation. The excited light was rather below the intensity which would easily allow of direct spectroscopic examination, but absorption methods have proved that the wave-length of the excited light must lie in the region between λ5820 and λ6020. There thus seems no reason to doubt that the emission consists of D light. (Ibid. p. 370, June 3, 1915.)—Both the D line and the line λ3303 are doublets. The question arises whether, if stimulation were confined to one member only of the ultra-violet doublet, we should get emission only of the corresponding member of the D line, or both components. The work of Wood and Dunoyer [Abs. 1527 (1914)] makes the first alternative the more probable, but the author has carried out an experiment which seems to decide fairly conclusively in favour of the second alternative. The Zn-arc spectrum has a doublet lying inside the ultra-violet sodium doublet, but while one component is situated at about 1/20 Å. unit from one sodium component, and is thus very nearly in coincidence, the other zinc component is four times as far from its Na neighbour, and well clear of it. A Zn vacuum arc in quartz was used to illuminate the Na-vapour bulb, interposing the filter as previously used for the suppression of visible light. With currents of 3 or 4 amps. nothing could be seen. Increasing the current to 6 amps. gave a faint emission of D light from the bulb. This was identified as before by absorption methods. At 15 amps. the light was bright enough for a specially designed spectroscope, and showed both components of the D line in about equal intensity. The current was increased successively to about 100 amps., but these large currents could only be kept on for a few seconds at a time. For this short time the fluorescence was not inferior in intensity to the light of a moderately salted Bunsen flame, and the components of the D line were seen very bright. The intensity increases very rapidly with the current through the lamp. This is due partly, of course, to the greater brightness, but more to the broadening of the first Zn component, which makes it definitely overlap the first Na component. Possibly at very large currents this cause may even bring the second Zn component on to the second Na component, but the first overlap must obviously come in much sooner; and at the lowest current which brings out the D line brightly enough for examination, its components are approximately equal. A. W.

855. *Optical Resonance in a Magnetic Field.* **L. Bloch.** (Comptes Rendus, 160. pp. 599–600, May 3, 1915.)—Treats the dissipation constant for longitudinal and transverse rays. [See Abs. 222 (1914) and 686 (1915).] E. H. B.

856. *Luminescence.* **E. Merritt.** (Phys. Rev. 5. pp. 319–334, April, 1915. Paper read before the Am. Phys. Soc., Dec., 1914.)—Discusses in some detail the phenomena and theory of luminescence. A brief outline of Wiedemann's theory, and the form of the theory advocated by Stark, Lenard, and others are given. Several well-established facts support the theory. For example, when fluorescence is excited in liquids or in isotropic solids the light emitted is unpolarised, regardless of the condition, as regards polarisation, of the exciting light. The absence of polarisation is one of the strongest arguments against any theory which assumes that the vibrations causing emission are set up by some process analogous to resonance. On the other hand, it is just what we should expect from Wiedemann's theory. Experiments made with excitation by light of different wave-lengths, by X-rays, and by kathodic bombardment, indicate that if a particular fluorescence band is excited at all, the distribution of intensity throughout the band is the same for all the modes of excitation thus far tested. This again supports the Wiedemann theory, for the effects produced when an electron reunites with the positive nucleus will be the same no matter what method was used in bringing about its dissociation. Similar reasoning would lead us to expect that the distribution of energy in a phosphorescence band will remain the same throughout the period of decay. On account of the faintness of phosphorescence spectra this conclusion is difficult to test with any high degree of accuracy; but in so far as it has been possible to test it the conclusion is confirmed. Studies of the law of decay of phosphorescence, while leading in many cases to confusing and even contradictory results, on the whole lend support to the Wiedemann theory. The phenomena of phosphorescence are extremely complex; and unfortunately the complexity appears to be especially great in the case of the substances that are most common and most frequently studied. In the further study of the subject it appears of the greatest importance to choose the conditions of observation so as to eliminate, if this is possible, some of the sources of disturbance. The work of Kennard at low temperatures [Abs. 72 (1915)] appears to be a promising step in this direction.

Stokes' law, that the wave-length of the fluorescent light is always longer than that of the exciting light, has led to extended discussion and experiment. The fact that there are many cases where the law is violated seems now to be well established. The most striking exceptions to the law are probably those found by Wood in the case of fluorescent vapours; but even in these cases the longest wave-length that will excite luminescence is only a little longer than the shortest wave-length in the light emitted. A satisfactory explanation of Stokes' law, based upon the theory of quanta, has been given by Einstein, and this explanation also accounts for the deviations from the law. The fluorescence spectra of the uranyl salts and of fluorescein are discussed, and it is noted, among other things, that there is a striking resemblance between the fluorescence spectra of the uranyl salts at low temperatures and the resonance spectra of vapours, but experiment has not gone far enough to make sure that the resemblance is more than superficial. The spectra of photoluminescence, complex as they often are, are the simplest spectra known. It may perhaps be thought that the high-frequency X-ray spectra possess greater simplicity. Possibly this is true. But the evidence of the most recent work does not support such a view; for as the methods of observation are improved there is every indication that the structure of these spectra is far more complex than was at first suspected. Seeman has recently obtained a photograph of part of the high-frequency spectrum of Pt that might well be taken for an arc spectrum.

It is interesting to note that in the high-frequency spectra we have phenomena that are highly suggestive of luminescence. Characteristic secondary rays are produced only by X-rays of wave-length shorter than that of the secondary rays emitted. This is the analogue of Stokes' law. For wave-lengths just a little shorter than that of one of its own characteristic rays a substance shows abnormally great absorption. We have here exactly the same relation between absorption and emission that holds in practically all cases of fluorescence. These absorption bands, plotted from results obtained by Duane, give curves which have the same form as those observed in such substances as eosin and resorufin with ordinary light. Except that the wave-length scale is a thousand times smaller, the phenomena of fluorescence appear to be duplicated in the high-frequency spectra in every detail. It would appear, therefore, that the arguments in favour of the study of luminescence spectra will apply equally well to the case of X-ray emission. A. W.

857. *Intensity Distribution of X-rays proceeding from a Graphite Antikathode.* **W. W. Loebe.** (Ann. d. Physik, 44. 7. pp. 1035–1052, July 17, 1914. Abbreviated Dissertation, Greifswald.)—The author describes four series of experiments and summarises his conclusions as follows:—(1) The intensity of the X-rays is a function of the angle which the direction of the kathode rays forms with the X-rays. (2) The maximum of intensity is displaced, with increasing hardness of the tube, towards the smaller angles, in agreement with Sommerfeld's calculations. (3) The intensity maximum is displaced towards the larger angles when the X-rays have to pass through metal: towards smaller angles when passed through glass. (4) Passage through graphite causes a displacement towards larger angles: very small for very hard tubes and slight for soft tubes. (5) At the angle 0° the intensity shows a distinct minimum. L. H. W.

858. *Interpretation of the Indications of Atomic Structure presented by Crystals interposed in the Path of X-rays.* **W. Barlow.** (Roy. Soc., Proc. 91. pp. 1–16, Nov. 2, 1914.)—A theoretical investigation to show that considerable translational and rotational distortion of the atomic orientation in crystals arranged according to any of the three space-lattices possessing

cubic symmetry can be effected so as to escape detection by the methods described by W. L. Bragg [Abs. 87 (1914)]. L. H. W.

859. *Distribution of the Electrons in Atoms.* **A. H. Compton, W. H. Bragg.** (Nature, 95. pp. 343–344, May 27, 1915.)—The spectra which are obtained by the diffraction of X-rays by crystals are characteristic both of the substance which emits the X-rays and of the crystal which acts as the grating. If the lines of an accurately ruled plane grating are small in width compared with their distance apart, the intensities of the different orders of spectra are nearly the same. If, however, the lines have a width comparable with the grating constant, the intensities of the higher orders rapidly diminish. When a crystal diffracts a beam of X-rays, the different layers of atoms correspond to the lines of the ordinary transmission grating, so that the relative intensity of the higher orders of spectra will depend upon the ratio, Effective diameter of the atoms in scattering the X-rays ÷ Distance between the successive layers of atoms. There are good reasons for believing that it is the electrons in atoms which scatter the X-rays. On this assumption it may be shown that if the density of the space distribution of the electrons in each layer of atoms is some function $f(z)$ of z, where the z-axis is taken normal to the reflecting planes, the ratio of the amplitude of the nth order spectrum to the amplitude it would have if all the electrons were in the same plane is—

$$P/P_0 = \int_a^b f(z) \cos(\beta + 2\pi nz/d)dz \Big/ \Big[\cos\{\beta + \pi n(b+a)/d\} \int_a^b f(z)dz\Big],$$

where $b - a = d$ is the grating space, and β is the phase angle of the reflected ray. If it is possible to find some function $f(z)$ which will lead to the values of P/P_0 as determined experimentally, an indication will be obtained of the distribution of the electrons in the atoms. From Bragg's data on rock-salt [Abs. 1840 (1914)] it can be shown that the intensities of the different orders cannot be accounted for by assuming that the atoms in the salt crystal are made up of single rings of electrons, or by assuming a uniform volume distribution of the electrons in spheres. A distribution which fits Bragg's data acceptably is an arrangement of the electrons in equally-spaced concentric rings, each ring having the same number of electrons, and the diameter of the outer ring being about 0·7 of the distance between the successive planes of atoms. If Webster's assumption that the trains of waves of the primary beam of X-rays are short compared with the distance which the rays penetrate the crystal is correct, certain corrections have to be applied to the experimental data, and on this assumption it can be shown that the average distance of the electrons from the centre of the atom is small compared with the distance between the atoms. Experiments are now in progress to test the validity of Webster's assumption and to determine more accurately the rate of variation of the intensity of the reflected beam with the order.

Bragg agrees with Compton in ascribing the rapid decline in the intensities of the X-ray spectra as we proceed to higher orders, to the fact that the atom should not be treated as a point but as a distribution of electrons in space. This hypothesis and its consequences were discussed by him in the Bakerian lecture [Roy. Soc., Phil. Trans. 215. pp. 253–274, 1915]. One or two of the points then raised are mentioned here. It is necessary to explain, not only why the intensities of the various orders fall off approximately as the inverse square of the number of the order, but also why atom-bearing planes give intensities whose reflections are proportional to the squares of the distances separating the planes. It appears that both laws follow from the same hypothesis; that which supposes the reflecting electrons to be distributed in space through the volume of the atom, and which imagines much overlapping to take place—atoms of one plane being thrust far into the interstices of the next. Experiment seems to fit in with these ideas. Probably, however, it is necessary to take account also of a difference in the distribution in different atoms. For example, certain results seem to indicate that the sulphur atom is more concentrated than the zinc. A. W.

860. *New Phenomenon Accompanying the Diffraction of X-rays in Birefringent Crystals.* **F. M. Jaeger**. (K. Akad. Amsterdam, Proc. 17. pp. 1204–1217, June 3, 1915.)—This paper commences with a discussion of the symmetry of a large number of crystals and their Röntgen-patterns. After considering the results obtained by earlier workers on this subject, the author describes a series of experiments on crystals of characteristic types. "The results of experiments carry the conviction that the theoretical views demonstrated at the beginning of this paper are quite insufficient to explain the phenomena, so soon as they are studied in biaxial crystals, instead of in optically isotropic or uniaxial crystals, radiated through parallel to their optical axes. . . . In biaxial crystals certain symmetry-elements of the Röntgenograms which were to be expected according to the Laue-Bragg theory vanish absolutely. . . . A final explanation cannot yet be given. In any case it has become quite evident that in the temporarily adopted theory for the diffraction-phenomena of Röntgen-rays in crystals, a certain factor is yet missing, which has the result that the consequences of the theory are in agreement with the experimental results only if it is applied to isotropic crystals or to those in which the transmission of the Röntgen-rays takes place in a direction in which the crystal behaves likes an optically isotropic one."

Excellent photographs and diagrams are reproduced in illustration of the various points raised in the paper. A. B. W.

861. *Photographic Effect of Recoil Atoms.* **A. B. Wood** and **A. I. Steven**. (Phys. Soc., Proc. 27. pp. 189–192, April, 1915.)—Measurements of the ranges of α-particles by different methods have shown that the ionising, phosphorescent, and photographic actions cease after the α-particles have traversed the same distance in air, although they still possess nearly 40 % of their initial energy. It seems reasonable to suppose, therefore, that these three properties of the α-rays must be ascribed to the same cause. The work of Wertenstein and also of Wood [see Abs. 258 (1914)] has shown that the ionisation produced by a recoil atom is about 10 times greater over its range than that produced by the corresponding α-particle over the same part of the range. It thus appears reasonable to expect that recoil atoms will produce phosphorescence and will affect a photographic plate. The object of experiments described is to investigate any photographic action if it occurs. An attempt is made, by two distinct methods, to demonstrate the photographic action of recoil atoms from polonium. The method of separating the α-particles from the recoil atoms by means of a magnetic field is undoubtedly more conclusive than the method of absorbing the recoil atoms, but, with the sources of polonium employed, the results show that the photographic effect, if any, of the recoil atoms is too small to be observed. This negative result may possibly be due to either or both of two causes, namely, (1) the activity of the polonium source used was not sufficiently great; (2) the recoil atoms do not penetrate sufficiently deep into the sensitive layer to produce an appreciable

photographic effect. By employing a source of very great activity both these difficulties might be overcome and a more conclusive result obtained. One of the authors has also carried out a series of experiments on the possibility of recoil atoms producing scintillations on a zinc sulphide screen, but the results in these experiments also are inconclusive. A. E. G.

862. *Absorption in Lead of the γ-Rays from Radium B and Radium C.* **H. Richardson.** (Roy. Soc., Proc. 91. pp. 396–404, June 1, 1915.)—In a previous paper by Rutherford and Richardson [Abs. 1675 (1913)] attention was drawn to the fact that the two types of γ-radiation emitted by RaB and RaC which are exponentially absorbed by Al both show irregular absorption curves when lead is used as the absorbing material. The present paper describes the method of determination and analysis of the absorption curves in lead for the two types of γ-rays just mentioned. In addition to the penetrating type of radiation for which $\mu = 0{\cdot}5$ (cm.$^{-1}$) in lead, RaC has been found to emit soft types for which $\mu = 46$, $\mu = 6{\cdot}0$ and $\mu = 1{\cdot}5$; these soft types are practically absorbed by 1·5 cm. of lead. Analysis of the RaB absorption curves show that in addition to the radiation $\mu = 40$ in Al, the rays emitted consist of three types for which $\mu = 46$, $\mu = 6{\cdot}0$ and $\mu = 1{\cdot}5$ for lead. These results are quite in agreement with those recently obtained by Rutherford and Andrade [Abs. 185 (1915)] in their determination of the spectrum of the penetrating γ-rays from RaB and RaC. The observations of these physicists indicate that part of the spectrum of RaB is not very different from that of RaC. Such a small difference of frequency in the radiations as is indicated by the above experiments would be difficult to detect by absorption methods. The absorption of the radiations in different heavy elements has been examined and the bearings of the results are discussed. No evidence of anomalous absorption has been found in the case of the penetrating radiations. A. B. W.

863. *Radium-content of Water from Gulf of Mexico.* **S. J. Lloyd.** (Am. J. Sci. 39. pp. 580–582, May, 1915.)—The growing recognition of radium as an important factor in geological processes has led to a multiplication of analyses of rocks and soils for that substance. With the object of obtaining further evidence on the question of the distribution of Ra in the ocean, which at a minimum estimate contains 1000 tons of Ra, the author has made a careful examination of the water of the Gulf of Mexico. The measurements were made in the usual type of vacuum emanation electroscope, and the results, with those of other observers, are included in the following table—

Observer.	Sea.	Gm. of Ra per Litre of Water.
Joly	Various oceans	17· × 10^{-12}
Eve (1907)	North Atlantic	0·8 × 10^{-12}
Eve (1907)	North Atlantic	0·9 × 10^{-12}
Satterly	English sea waters	1·0 × 10^{-12}
Lloyd	Gulf of Mexico	1·7 × 10^{-12}

Excluding Joly's abnormally high results, an average value for the Ra-content of 1 litre of sea water is 1·2 × 10^{-12} gm., representing a total amount of 1400 tons in the sea. According to the author, 100 litres of sea water should contain from 0·3 to 0·5 mgm. of uranium. A. B. W.

HEAT.

864. *Determination of the Coefficients of Thermal Conductivity by the Cooling of Spheres.* II. **F. Vercelli.** (N. Cimento, 8. pp. 408–414, Dec., 1914.)—The author has applied the method previously described [Abs. 1481 (1914)] to the measurement of the thermal conductivities of two spheres of marble. For each specimen concordant results were obtained, the values of K in gm. cals. per cm.-sec.-degree being for (1) a compact, white, fine-grained marble, 0·00815 and (2) a coarser marble, slightly veined with black, 0·00664. These results are in good agreement with those obtained by other authors. T. H. P.

865. *Heat Transmission Capacity of a Silica Dish.* **W. K. Lewis.** (J. Eng. Chem. 7. pp. 410–414, May, 1915. Thesis by **A. H. Spaulding.**)—A silica dish charged with water, sulphuric acid, or zinc chloride (boiling-point 240° C.), is placed over a cylindrical gas furnace (brick setting), in which gas is kept burning with a non-luminous flame. The temperature of the lower surface of the silica dish (66 sq. in. exposed to flame—no further information) is determined at different distances from the centre of the dish by means of thermo-couples, whose mounting is not explained; the water boiling off is replenished, but not measured as it escapes. It is found that the temperature of the dish diminishes at a regular rate from the centre to the edge of the dish, and that the total drop increases as the temperature of the gas under the centre is raised. In some experiments the flame was not allowed to touch the dish; the gas-burner was removed from the furnace, but all the hot gases were conveyed to the furnace through a horizontal flue. It is deduced that the average temperature to be used in calculating the heat transfer is the temperature at the centre of the heated area less two-thirds of the total drop in temperature to the edges. Formulæ are proposed for allowing for contraction, convection and radiation of heat, in accordance with Langmuir's views as to the transfer of heat from a hot gas to a solid; the coefficients of the terms of the formulæ are given, but there are no quantitative data. Suggestions are made as to the construction of furnaces for concentrating sulphuric acid, etc. Further papers are to follow. H. B.

866. *Specific Heat, c_p, of Air at 60° and 1–200 Atmospheres.* **L. Holborn** and **M. Jakob.** (Zeitschr. Vereines Deutsch. Ing. 58. pp. 1429–1436, Oct. 3, 1914.)—Owing to the disparity between the values obtained for the specific heat of air, c_p, at high pressures, the authors have made a new series of measurements by passing a regular current of G kilogrammes of air per hour at constant pressure through a calorimeter, in which it is heated from the temperature t_1 to t_2 by Q units of heat per hour applied electrically. If in this way V units of heat are lost per hour, $c_p = (Q - V)/G(t_2 - t_1)$. The construction of the compressor, the calorimeter, the throttle valve, the gas measurer, and the connections is described, and also the methods of measuring the amounts of air and heat, and the temperature and pressure. The value of c_p is calculated by means of the equation, $Q_r = G_L(t_2 - t_1)c_p + V_t$, where Q_r is the amount of heat used and G_L the weight of dry air heated per hour. These observed values of c_p are compared with those calculated from the empirical formula, $10^4 c_p = 2413 + 2{\cdot}86p + 0{\cdot}0005p^2 - 0{\cdot}00001p^3$. The value, 0·2418, obtained for c_p at 59° and 1 atmo. pressure agrees satisfactorily with those obtained by Swann [Abs. 1280 (1910)], namely 0·2412 at 20°, and Scheel and Heuse [Abs. 504 (1912)], namely 0·2409, all these numbers differing markedly from Regnault's value, 0·2374 (Rel. des exp. II. p. 108, 1862). The following table gives the author's values of $c_p \times 10^4$ for 59° and for various pressures in kg. per cm.^{2}, those of Lussana [Abs. No. 48 (1899)], and those derived from the throttling experiments of Joule and Thomson, Vogel [1911] and Noell [1913] by Linde's formula, $c_p = c_0(1 - d\delta/dT)$, where c_0 is the specific heat at pressure 0 and δ the cooling when the pressure is reduced by throttling from p to a vanishing small value.

p.	Author's obs.	Author's calc.	Lussana.	Joule and Thomson.	Vogel.	Noell.
0	—	2413	—	—	—	—
1	2415	2416	2370	—	—	—
25	2490	2485	2711	2481	2480	2493
50	2554	2556	3061	2557	2548	2568
100	2690	2694	3675	2721	2664	2701
150	2821	2819	4198	2919	2770	2812
200	2925	2925	—	3150	2858	2893

T. H. P.

867. *Specific Heat and Heat of Fusion of Ice.* **H. C. Dickinson** and **N. S. Osborne.** (Power, 41. p. 565, April 27, 1915.)—It was found by A. W. Smith [see Abs. 1970, 2986 (1904)] that the specific heat of ice was practically constant up to the melting-point, a result which disagreed with the work of some previous experimenters. This paper describes a fresh investigation, using 4 samples of distilled water of varying degrees of purity. The calorimeter used was of aneroid type, *i.e.* without stirred liquid as calorimetric medium. Over the range of temperature covered by the experiments (—40° to —0·05° C.) the specific heat S at any temperature θ is found to be given by $S = 0{\cdot}5057 + 0{\cdot}001863\theta - 79{\cdot}75l/\theta^2$, where l is a constant decreasing in value with increasing purity of the water (0·0012 to 0·00005 for the samples used). It is concluded that for pure water $l = 0$ to a close approximation. The determinations of the heat of fusion give a mean value of 79·76 gm. cals., the unit employed being the 20° calorie. A table of total heats of ice and water (in B.Th.U. per lb.) concludes the paper. J. W. T. W.

868. *Ratio of Specific Heats by Speed of Sound.* **A. Leduc.** (Comptes Rendus, 160. pp. 601–603, May 3, 1915.)—After reviewing a number of results obtained on this method the author considers it scarcely suitable and satisfactory for vapours, and asserts that it is desirable to develop some other method. E. H. B.

869. *The Mercury-resistance Thermometer as a Reproducible Empirical Temperature Scale.* **W. Jaeger** and **H. v. Steinwehr.** (Ann. d. Physik, 43. 8. pp. 1165–1185, April 16, 1914. Communication from the Physikal-Techn. Reichsanstalt.)—Owing to the fact that the calibration of the Pt-resistance thermometer is to a certain extent an inconvenient operation, it was found desirable to obtain thermometers which should be free from this disadvantage, and which should represent a completely reproducible temperature scale

independent of any individual characteristics of the thermometer. The only material for this purpose which is easily obtainable in a sufficiently pure state is mercury; and in order to avoid the disadvantage of having to allow for expansion it is necessary to employ a quartz container. The useful working range of such a thermometer lies between − 30° and + 360° C., but the present investigation concerns only the interval 0° to 100° C. The question here investigated is, whether various thermometers of this type actually show completely concordant resistance-changes. The method of comparison with the Pt-thermometer is fully detailed, and results of a typical test are worked out. As a result it is found that the readings of two such Hg-resistance thermometers agree completely within the limits of error of a few millionths.

The question of the relation of this scale to that of the Pt-thermometer, and in that way with the absolute temperature-scale, will be dealt with in a later paper. L. H. W.

870. *Boiling-points of Aqueous Solutions of Nitric Acid at Different Pressures.* **H. J. M. Creighton** and **J. H. Githens.** (Frank. Inst., J. 179. pp. 161–170, Feb., 1915.)—Data and curves are given for the boiling-points of complete series of mixtures of nitric acid and water under pressures of 110, 250, 360, and 760 mm., for the vapour-pressures at different temperatures of solutions containing 20, 30, 40, 50, 60, 70, 90, and 99·79 % HNO_3 and for the vapour-pressures of a series of solutions of nitric acid at 75°, 85°, 95° and 100° C. Special interest attaches to the mixtures of max. boiling-point, which have the following properties:—

Pressure.	Boiling-point.	Composition.
760 mm.	121·70° C.	68·18 % HNO_3
360 „	99·9° „	67·15 „
110 „	74·2° „	66·80 „

T. M. L.

871. *Temperature Measurements of Anisotropic Bodies by Means of Radiation Pyrometers.* **F. M. Jaeger** and **A. Šimek.** (K. Akad. Amsterdam, Proc. 16. pp. 799–807, 1914.)—An account of a striking experiment having as its object the demonstration, that if a radiating object (such as a birefringent crystal) is anisotropic with respect to its absorption for radiant energy, it must also be anisotropic with respect to its emission, in accordance with Kirchhoff's fundamental law. The body will behave, therefore, as if it had different temperatures in different directions of vibration: its apparent radiation temperature will not be the same for different vibration directions of its emitted radiation. Pflüger has already demonstrated the law of Kirchhoff for this case [Abs. 1860 (1902)], but the improvements in radiation pyrometers effected since that time allow of a more simple and effective way of showing the effect.

A dark green crystal of Brazilian tourmaline furnished two small cylinders of 2 or 3 mm. diam. and 1 mm. thickness, one with its axis parallel to the crystallographic axis of the mineral, the other perpendicular to it. When placed in an electric furnace fixed in a horizontal position, and with a Haidinger dichroscope eyepiece placed before the Holborn-Kurlbaum type pyrometer, two images of the objective, an ordinary and an extraordinary one, were obtained, as though the object was divided into two halves. At a temperature of 769° C. it was then found that the lower field had a radiation temperature of 757° C., the upper one of 769° C. As the upper field corresponds with that direction of vibration wherein the max. absorption of radiant energy takes place, so the apparent temperature should also seem higher in that field, as was found to be the case. L. H. W.

872. *New Graphical Application of Regnault's Hygrometric Formula.* **J. Loisel.** (Comptes Rendus, 160. pp. 370–372, March 22, 1915.)—The present note contains a geometrical discussion of Regnault's formula for the tension of aqueous vapour, viz., $f=f'-Ah(t-t')$, where t and t' are the temperatures of the dry and wet bulbs respectively, f' is the max. vapour-tension of water, h the atmospheric pressure, and A the hygrometric constant. By suitable transformations a simple graphical rule for applying the formula has been deduced. H. H. Ho.

873. *Planck-Einstein Energy Formula derived without Hypothesis of Quanta.* **S. Ratnowsky.** (Deutsch. Phys. Gesell., Verh. 17. 4. pp. 64–72, Feb. 28, 1915.)—A preliminary account of a theory in which the endeavour is made to derive the formula for the energy at absolute zero without having recourse to Planck's quantum hypothesis. [See Abs. 1014, 1016 (1913).] E. H. B.

874. *Degrees of Freedom of Groups of Rays.* **M. v. Laue.** (Ann. d. Physik, 44. 8. pp. 1197–1212, Aug. 4, 1914.)—Jeans has given a fundamental law expressing the number of degrees of freedom of radiation within an enclosure with perfectly reflecting walls and of large size compared with the wave-lengths [Abs. 1690 (1905)], but was not able to obtain formal proof of the distribution of energy among the various wave-lengths being independent of the shape and material of the enclosure as required by Kirchhoff's law. H. Weyl has proved this [Math. Ann. 71. p. 441, 1911], by the aid of recondite mathematical considerations, for enclosures with perfectly smooth and perfectly reflecting walls. The author here shows, by mathematical methods generally familiar to physicists, that it applies also to enclosures with any kind of walls, the method followed being the decomposition of the radiation into independent groups and the counting of the degrees of freedom in each group. G. W. de T.

875. *Value of Joule-Thomson Observations for Computing Steam Tables.* **H. N. Davis.** (Phys. Rev. 5. pp. 359–367, May, 1915.)—In order to place the steam tables at present available on a thoroughly satisfactory basis, a complete and accurate series of Joule-Thomson or throttling experiments is required, together with a series of experiments on the specific heat of water, especially at high temperatures. The author discusses briefly the theory underlying Joule-Thomson observations, which, if carried out with a heating coil, as suggested by Buckingham (1903), yield a direct determination of the specific heat of superheated steam, and are able indirectly to furnish valuable information about this specific heat by means of the methods described by Dodge, by Davis, and by Grindley. T. H. P.

876. *Saturated Vapour Refrigerating Cycles.* **J. E. Siebel.** (Science, 41. pp. 804–805, May 28, 1915. Paper read before the Am. Assoc. for Advancement of Science.)—The author analyses the energy conversion in refrigerating cycles conceived to be operated perfectly reversible by a saturated vapour with negative specific heat (steam as a representative).

Accordingly, it is found that the work required to produce a certain amount of refrigeration in such a cycle is greater than in a refrigerating cycle operated reversibly by dry vapour of the same medium. In the latter case the relation between the work W and the produced refrigeration Q is expressible by the equation $W = Q(t - t_0)/T$, while in the former it must be expressed by $W = (Q + Q_1)(t - t_0)/T$, Q_1 representing the amount of heat which is to be withdrawn in the compression stage to keep the vapour saturated in a cycle operated between the temperatures t_0 and t, T representing the temperature t in absolute degrees. L. H. W.

877. *Measurement of Vapour-pressure Lowering by the Air-saturation Method.* **E. W. Washburn** and **E. O. Heuse.** (Am. Chem. Soc., J. 37. pp. 309–321, Feb., 1915.)—An apparatus is described with which values of $(p_0 - p)/p_0$ having a magnitude of about 0·02 can be measured with an accuracy of 0·5 %, or better, in a 24 hours' run. This is about 10 times better than the usual dynamic method, and about equal to the results obtained by Berkeley, Hartley, and Burton in a 3 days' run. The static method as recently used by Fraser and Lovelace gave slightly better results, but required 8 days for the final equilibrium to be attained. T. M. L.

878. *Quantum-theory of Radiation and Line Spectra.* **W. Wilson.** (Phil. Mag. 29. pp. 795–802, June, 1915.)—In his report on radiation and the quantum-theory, Jeans, dealing with theories of line spectra, remarks that Bohr's assumption is "not inconsistent with the quantum-theory, and is closely related to it." This suggests the possibility of deducing the results of Planck and Bohr from a single form of quantum-theory. Such a theory is developed in the present paper, and it will be seen that it contains that of Planck (in one of its forms) as a special case, and, while formally distinct from Bohr's theory, leads to the same results when applied to the Rutherford type of atom. The theory is based on the following hypotheses: (1) Interchanges of energy between dynamical systems and the ether, or between one dynamical system and another, are "catastrophic" or discontinuous in character. That is to say, each system behaves as a conservative one during certain intervals, and between these intervals are relatively very short ones during which definite amounts of energy may be emitted or absorbed. (2) The motion of a system in the intervals between such discontinuous energy-exchanges is determined by Hamiltonian dynamics as applied to conservative systems. A system during such an interval is said to be in one of its steady states. From these hypotheses general expressions are derived for the distribution law, and for the average energy of a system. Applied to Planck's oscillators these give respectively $f_p = (1 - e^{-h\nu/kT})\, e^{-ph\nu/kT}$ for the law of distribution of the oscillators among the different loci, and $\bar{E} = h\nu/(e^{h\nu/kT} - 1)$ for the average energy of an oscillator, both results being the same as in Planck's theory. Planck's radiation formula can also be deduced. It is shown that Bohr's assumptions, in so far at any rate as we restrict ourselves to the type of atom or emitting system to which Bohr's theory has been applied with some measure of success, can be immediately deduced from the theory given. The further application of the theory to line spectra and other phenomena will be given in a subsequent paper. A. W.

879. *Integration of Thermodynamic Equations for an Imperfect Gas.* **S. A. Moss.** (Phys. Rev. 5. pp. 426–444, May, 1915.)—The two laws of thermodynamics give certain differential equations connecting the heat capacities of a substance with its pressure-volume relations, which have been integrated in special cases. A general integration is here made. The case of total heat is first considered, and is followed by an exhaustive treatment of thermal notation and definitions. Fundamental differential equations next receive attention, and then the relation between total heat and volume. The total heat and entropy of an imperfect gas from volume, as also from volume and specific heat at zero pressure, are discussed in great detail. Following this comes a deduction of saturation values from volume and specific heat at zero pressure. The Callender, Goodenough, and Heck characteristic equations for steam are then dealt with by the author. Finally, the effect is considered of taking the saturation equation instead of specific heat at zero pressure. In previous cases the assumption has been made that one of the initially given relations is the specific heat of gas at zero pressure, and this leads to an expression for the saturation equation; the author now gives the mathematical theory of a reversal of this method in which the experimentally established saturation equation is used as a basis in addition to the general value of the volume. When experimental or other data regarding total heat are available, then by a reverse process values of volume may be obtained.

H. H. Ho.

880. *Change in Thermal Conductivity of Metals on Fusion.* **A. W. Porter** and **F. Simeon.** (Phys. Soc., Proc. 27. pp. 307–314; Disc., 314–315, June, 1915.)—The change in question was determined for mercury and for sodium by finding the temperatures at different points of a cylinder of the metal contained in a glass tube. The ends of the cylinder were maintained at such temperatures that the metal was liquid half-way down its length, the remaining part being solid. The temperatures were taken by means of thermoelectric junctions inserted in narrow tubular depressions which had been formed in the glass tube by forcing a knitting needle down into the locally heated glass. The ratio of the thermal conductivity for solid and liquid was estimated from the slope of tangents drawn to the temperature-curve on each side of the melting-point. The values of these ratios are of the same order as the ratio of the corresponding values of the electrical conductivities. The mean value for mercury is 3·91, and for sodium 1·31.

A summary list is given of other data concerned with fusion. AUTHORS.

SOUND.

881. *Wave Motion round a Transversely Vibrating String in an Unlimited Fluid.* **A. Kalähne.** (Ann. d. Physik, 45. 5. pp. 657–705, Oct. 15, 1914.)—A mathematical treatment of which the chief results are as follows :—(1) The stationary state of motion of an unlimited medium in the neighbourhood of a transversely vibrating, infinitely long string and the energy current are determined. (2) Two different stationary states are possible, which are mathematically distinguished by the real or imaginary values of a certain quantity K which occurs in the argument of the cylindrical function for the velocity potential. In the critical case the value of K is zero. (3) If K is real, progressive waves occur ; if K is zero or imaginary, the stationary state consists of stationary waves in the entire medium. In both cases the amplitude decreases as we pass outward from the string. (4) The physical significance of the three kinds of values of K is the following. For real values of K the speed of propagation of transverse waves along the string and their wave-length exceed respectively the sound speed and wave-length in the medium ; for imaginary values of K the reverse holds good, while for K equal to zero the two speeds are equal. (5) Only for real values of K is a sustained energy-current, or radiation, outward from the string possible. By imaginary and vanishing values of K the energy state fluctuates during each period to and fro in the medium. And, for these values, radiation of energy from the string into the space only occurs prior to the attainment of the stationary state. (6) The total energy radiated prior to the establishment of the stationary state, and which remains unchanged in the space while this state lasts, is finite for K imaginary but is infinitely large for K equal to zero. E. H. B.

882. *Theories of Voigt and Everett regarding Origin of Combination Tones.* **W. B. Morton** and **M[ary] Darragh.** (Phys. Soc., Proc. 27. pp. 339–354 ; Disc., 355–356, June, 1915.)—Voigt connects the existence of difference and summation tones with the fact that the stationary points of the compound vibration-curve, when the primary tones have equal energies, can be grouped in a certain way on sine curves, which recur in the periods of these combination tones. As against this view it is urged (1) that the same points can equally well be grouped on a whole series of curves with other frequencies ; (2) that the distinctness of the combination-tones would on this theory vary greatly with the phase-relationship of the primaries ; (3) that the tones would disappear when the energies of the primaries are not very unequal. Voigt applies a similar method to the case where the upper tone is weak compared to the lower to account for Koenig's second beat-tone. The first of the above objections again applies.

Everett supposed that the distortion of the vibration-curve in passing through the ear would bring in the note whose frequency is the highest common factor of the primary frequencies. The effect of a special kind of distortion has been tested, consisting in a proportional reduction of ordinates in one direction. The result does not confirm Everett's contention, but shows the appearance of the summation and difference tones. AUTHORS.

883. *Speed of Sound in Gaseous Mixtures.* **A. Leduc.** (Comptes Rendus, 160. pp. 516–519, April 19, 1915.)—Numerical and other illustrations of the views previously developed [see Abs. 705 (1915)]. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

884. *Brownian Movements and Ne for Hydrogen.* **C. F. Eyring.** (Phys. Rev. 5. pp. 412–417, May, 1915.)—Values of N*e* for gaseous ionisation have been determined by Townsend, Franck and Westphal, Fletcher, and others. By means of the measurement of the Brownian movements of a small oil-drop, Fletcher in 1911 made a direct determination of N*e* for ionised air, and more recently determined by the same method the value of the Avogadro constant N for air. The present article extends the Brownian movement method of Fletcher to the study of hydrogen with the view of testing the method in the case of gases other than air, and of determining directly the value of N*e* for hydrogen.

The experiments led to the result $Ne = 2·880 \times 10^{14}$. The value from electrolysis is $2·896 \times 10^{14}$. The investigation accordingly leads to the conclusion that the Brownian movement method holds for gases other than air, and that the molecules of ionised hydrogen carry the same charge as the hydrogen ions of electrolysis. [See Abs. 662 (1908), 1652 (1911).] E. H. B.

885. *Induction in Dielectrics in Motion in a Magnetic Field.* **L. Slepian.** (Ann. d. Physik, 45. 6. pp. 861–880, Nov. 3, 1914.)—Ebonite, paraffin, and sulphur, rotating in a magnetic field, show an electric displacement, proportional to the velocity of the rotation and to the magnetic induction of the field, and agreeing in amount with Lorenz's theory. Other cognate phenomena also in harmony with Lorenz's theorem are discussed. There is no electric displacement in air in motion in a magnetic field. Hertz's theory is not in accord with the results obtained. A. D.

886. *Numerical Relations between Electronic and Atomic Constants.* **H. S. Allen.** (Phys. Soc., Proc. 27. pp. 425–431; Disc., 431, June, 1915.)—It has been pointed out by Jeans that hc, where h is Planck's constant and c is the velocity of light, has the same physical dimensions as the square of an electric charge. Lewis and Adams have suggested a relation between these quantities of the form—

$$ch = \sqrt[3]{\frac{\pi^5}{15}}(4\pi e).$$

This may be written—

$$\frac{2\pi e^2}{hc} = \frac{(15/\pi^2)^{1/3}}{(4\pi)^2} = q,$$

where q is $7·28077 \times 10^{-3}$. The square of this numerical constant is $p = 5·30096 \times 10^{-5}$. The charge e on an electron in e.s. units is found to be, within 0·1 per cent., $9p \times 10^{-6}$. The ratio e/m of the charge to the mass is found to be $p \times 10^{22}$, with the same order of accuracy. The occurrence of powers of 10 in these expressions may be accidental or may depend on the way in which the units of length, mass, and time were originally defined. Derived quantities, depending on e, m, and c, can be expressed in terms of simple integers (2, 3 or 4), powers of 10, p and π. The "atomic mass of an electron" is approximately $10p$. AUTHOR.

887. *Effect of Electric Tension on the Surface of an Insulating Liquid.* **L. Bouchet.** (Comptes Rendus, 160. pp. 554–556, April 26, 1915.)—A previous investigation on the deformation of caoutchouc under electric tension has led the author to extend his work to the case of the free surfaces of such insulating liquids as vaseline, benzol, petroleum ether, etc. Here complex effects due to the elasticity of solids are avoided, while in addition liquids are better defined as dielectrics. The liquid is placed on one of the plates of a plane condenser and separated by an air space from the other plate, being then subjected to known electric tensions. The following arrangement has been devised for measuring the deformation produced: The condenser plates are two large brass discs, of which one constitutes the base of a vessel otherwise made of ebonite containing the liquid, while the other disc can be maintained parallel to the liquid surface at an adjustable distance. Microscopic observations of the free surface are made exterior to the apparatus by means of a glass tube passing through the wall of the ebonite vessel and inclined outside. A p.d. of 5150 volts was abruptly established between the plates and the displacements of the liquid meniscus in the external tube were measured. These were rapid, but were also accompanied by a slower effect in the case of non-conducting liquids, which effect was absent for conductors like water and mercury. The ratio of the level-changes in the case of water and mercury was equal to that of the inverse of their densities, but with turpentine the level-change, although rapid at the outset, continued for about 2 mins., terminating at the depression limit required by the conductivity in accordance with some observations by Malclès on the conductivity of ordinary dielectrics. In the cases of vaseline, benzol, and petroleum ether, the complete effect could not be determined owing to the prolonged duration of the phenomenon, but a good approximation was arrived at by plotting a depression-time curve. Taking the force on the liquid surface as $H^2K(K-1)/8n$, where H is the field strength in the liquid interior and K the true dielectric constant, and equating this to the weight of displaced fluid, K can be determined.

Agreement between the values of K by this depression method and by the electrometer is very good. H. H. Ho.

888. *Change of Dielectric Constant with Temperature.* **F. Schmidt.** (Ann. d. Physik, 44. 2. pp. 329–336, May 12, 1914.)—Investigates the change in the dielectric constant with temperature for sulphur and for the CaBiNa-phosphorus [prepared according to Lenard and Klatt, Abs. 726 (1905)]. The change was expected to be so small that a special differential method of employing two oppositely charged condensers was used. The mean change per 1 deg. C. was 0·0010 and 0·0021 respectively for the two substances over the interval 16° to 140° C.

The larger change in the CaBi-phosphorus is in accord with what was expected in view of its phosphorescent properties. L. H. W.

889. *On Self-intersecting Lines of Force and Equipotential Surfaces.* **G. B. Jeffery.** (Phil. Mag. 29. pp. 832–836, June, 1915.)—Gives some extensions of Rankine's theorem regarding equipotential-surface sheets and some analogous results for lines of force. L. H. W.

890. *Calculation of Electrostatic Capacities of Long, Straight Cylinders.* **T. Otake.** (Kyushu Univ. Coll. of Engin., Mem. 1. No. 1. pp. 31–77, 1913.)—Obtains the distribution of the potential due to a charged straight cylindrical conductor, of infinite length and having a certain geometrical cross-section, by means of the principle of conformal representations due to Schwarz. An expression for the electrostatic capacity is then found.

L. H. W.

891. *Diurnal Variation of Earth's Penetrating Radiation.* **L. J. Lassalle.** (Phys. Rev. 5. pp. 135–148, Feb., 1915.)—The investigation described in this paper is one of a series of four undertaken to determine the ultimate cause or causes of the radio-activity of the earth. After describing the experimental methods adopted in the present research, the author gives tables of results showing the variation of intensity of the radiation at different times. From these and many similar sets of tables the following conclusions are drawn: (1) A diurnal variation in the value of N, the number of ions per cm.^{3} per sec. formed in a closed vessel in Manilla (Philippines), was found: the mean for N is found to be 7·48. The maximum of 8·96 occurs at 4 p.m. and the minimum of 4·94 at 10 a.m. (2) It seems probable that the main causes of the ionisation are the radio-active materials in the soil and the radio-active matter in the atmosphere. (3) Since there is no reason to suppose that the former of these two causes might have a diurnal variation, it must be that this variation takes place in the latter cause. (4) The air-currents at Manilla have a diurnal variation, and it seems probable that the variation in the amount of radio-active matter in the atmosphere is due to this cause. A. B. W.

DISCHARGE AND OSCILLATIONS.

892. *Carbon Arc under Pressure and Production of Sun Temperature.* **O. Lummer.** (Review by H. Lux in Elektrot. Zeitschr. 35. pp. 1116–1118, Dec. 17, 1914. Electrician, 75. pp. 517–518, July 9, 1915.)—Describes an investigation of the temperature of vaporisation of carbon, in the course of which an attempt was made to measure the temperature of the positive crater of a carbon arc under various pressures. By the employment of the interference pyrometer it was possible accurately to measure the black-body temperatures of very small elements of the carbon. As the carbon was found to radiate in the visible spectrum as a grey body, it was possible by using as comparison body a carbon filament glow-lamp, to deduce the true temperatures, extrapolation being made according to the relation $(H_1/H_2) = (T_1/T_2)^x$, in which H_1 and H_2 are the brightnesses corresponding to absolute temperatures T_1 and T_2, while x is assumed to have the value 8·5. The true temperature of the crater at atmospheric pressure is found to be 4200° abs., while that of the negative crater is usually some hundreds of degrees lower. At 0·1 atmo. the temperature of the carbon fell to 3940° abs., the intrinsic brightness being only 0·59 of that at atmospheric pressure. In the high-pressure investigation it was necessary to use impregnated carbons, an increase of pressure to 22 atmos. being found to raise the temperature to 6000° abs. (above sun temperature on the assumption that solar radiation is that of a grey body) and the intrinsic brightness to 18 times that at atmospheric pressure. This temperature is deduced on the assumption that the impregnated carbon also radiates as a grey body in the visible spectrum.

J. W. T. W.

893. *Ionisation by Positive Rays.* **N. Campbell.** (Phil. Mag. 29. pp. 783–794, June, 1915.)—Comparatively little is known concerning ionisation by the impact of atoms except when the atoms are those constituting α-rays. Bahr and Franck [see Abs. 933 (1914)], and Pawlow came to the surprising conclusion that the positively-charged particles from hot Pt and hot phosphates, can ionise gases when their energy is less than that required by electrons. This result is of the greatest importance for theories of the structure of the atom, for it would seem to indicate that the "ionisation potential" for electrons has not the fundamental significance which has often been attributed to it. It appears that further experiments, especially on the variation of the ionising power of positive particles with their speed, energy, or charge are desirable. Recent work has tended to show [Abs. 587 (1915)] that the liberation of electrons, which takes place when ionising rays of any kind fall upon a metal surface, varies with the properties of those rays in precisely the same manner as the ionisation which the rays cause in a gas. Indeed, it is highly probable that, when the surface of the metal has been recently polished, the electrons are actually liberated from a layer of gas on the surface of the metal. Experiments on such metal surfaces are free from many of the difficulties which attend experiments on ionisation in a gas which has any appreciable volume. In the present experiments the positive particles are those liberated from heated phosphates. The use of such particles is necessary if their effect is to be investigated for very low potentials at which a discharge will not pass; it has the additional advantage, even at higher potentials, that the observations can be made at a very low vacuum and the ionisation be completely localised at the metal surface; it has the disadvantage that greater uncertainty exists as to the nature of the particles. The particles are liberated at a heated strip which is of Pt coated either with sodium phosphate or a mixture of sodium and aluminium phosphates, and the liberation of electrons from the surface of a copper plate struck by these positive particles from heated phosphates has been studied. Figures are given which show the relation between P, the number of electrons liberated by each positive particle, and V, the p.d. through which the particles have fallen, and also the relation between V and R, the reflection-coefficient of the positive rays. It is suggested that the fall in P for the largest values of V may be due to the beginning of the stage at which the particles can penetrate the surface-layer of the metal, exhibiting one of the properties which distinguish α-rays from canal-rays. At the highest potentials which could be studied no indication was obtained of the acquirement by the positive particles of the other distinctive property of α-rays, the great ionising power. A. E. G.

894. *Secondary Kathode Radiation.* **F. Mayer.** (Ann. d. Physik, 45. 1. pp. 1–28, Aug. 14, 1914.)—The capability of the primary kathode rays to liberate secondary radiation is a function of the velocity. Below a certain limit no secondary radiation takes place (11-volt limit); above this velocity a maximum of secondary radiation is attained, and beyond this, at still greater velocities, the secondary radiation again falls off. The first part of this paper deals with the determination by the most accurate means possible of the limits of the velocity for certain definite substances. The second part gives an account of the numerical determination of that velocity value of the primary kathode rays at which the maximum of the formation of carriers occurs. The third part deals with new absorption measurements of kathode rays of very small velocity. (1) The following values were obtained for the smallest primary velocities necessary for the formation of kathode rays in the case of six different gases:—

For	Air	H	N	CO_2	CH_4	CO
	9·5	11·5	11·8	12·5	13·5	14·5 volts

(2) The optimum value of the primary velocity for secondary radiation the existence of which was found by Lenard, but whose exact value has not been hitherto determined, was found to be as follows:—

For	Air	H	N	CO_2	CH_4	CO
	130	125	150	140	132	125 volts

(3) Beyond the optimum radiation value at higher primary velocities, with the gases investigated the falling-off of intensity occurred more quickly the smaller the radius of the gas molecule concerned. Hydrogen departs from this rule, since its capacity for secondary radiation decreases more slowly than would correspond to its molecular radius. (4) In the region between the smallest primary velocity necessary for the liberation of secondary kathode rays and the optimum for secondary kathode radiation it has not been possible to find a measurable connection between secondary radiation and the related constants of the substances. The gases behave in a separate and individual way. The curve for H, however, is exceptional; after a flat portion at the beginning it rises more steeply than the corresponding curves for other gases. (5) In the radiation optimum the secondary quantity for gas-kinetic average is proportional to the absolute mass of the molecule. (6) The absorption coefficients for kathode rays of very small velocity (0·5 to 3 and 0 to 4·2 volts) in air may be deduced within this interval from the constant of the absorbing cross-section. J. J. S.

895. *Selective Photoelectric Effect and the Normal Photo Effect.* **R. Pohl** and **P. Pringsheim.** (Journ. de Physique, 5. pp. 525–545, July, 1914. Paper read before the Soc. franç. de Physique, April, 1914.)—Deals at length with the work carried out by the authors. [See also Abs. 719 (1914).]

896. *Production of Rare Gases in Vacuum Tubes.* **R. H. Goddard.** (Science, 41. pp. 682–684, May 7, 1915.)—A number of investigators have found that helium and neon are produced in vacuum tubes by electrical discharges. These gases were not accompanied by argon, and therefore not due to leaks in the apparatus. A thoroughly satisfactory explanation of the appearance of the gases remains to be given. Winchester finds that He and Ne are given off from Al electrodes only during the first few hours of long-continued discharges, and he therefore concludes that the gases must have been occluded on the surfaces from the atmosphere. This explanation agrees with a number of facts. There is an alternative explanation which fits the facts equally well, if we admit the possibility of changes of a radio-active nature taking place in an ordinary vacuum tube. But there is, in the first place, no good evidence that ordinary inactive matter can be transformed by the radiations of radio-active substances. It appears that all electrodes hitherto employed in the production of rare gases have had a layer of oxide on the surface—traces of which must have remained until all the original surface had been removed by the action of the discharge. In view of this fact it seems desirable that a tube be constructed, with electrodes similar to those used by Winchester, it being possible to clean these electrodes

mechanically on all sides, *in vacuo*, the apparatus, moreover, occupying but a small volume. An apparatus is described which embodies the above essentials. A. E. G.

897. *Corona in Air.* **D. MacKenzie.** (Phys. Rev. 5. pp. 294–310, April, 1915.)—Wires of diameter 0·165, 0·157, 0·107, and 0·063 cm. were used. The wire was surrounded by a metal tube and both were enclosed in a glass cylinder containing air, the pressure of which could be varied. The available d.c. voltage was 2700. The starting-point of the corona was detected by means of a small disc, placed near the outer surface of the metal cylinder, and connected to a charged electroscope. Just opposite the disc there were holes in the metal cylinder, through which ions could pass. When the corona starts the gold-leaf drops, the voltmeter is read, and the air pressure is noted. The following results were obtained:—(1) The formation of the stable negative corona has been shown to be dependent upon the pressure and the size of the conductor. Of the wires used, with those of larger diam. such a corona is never formed, while around the smaller wires the negative corona can exist only at pressures greater than a critical value which varies with the diam. of the wire. (2) The transition has been observed from the stable corona to the vacuum-tube discharge. The latter is the only luminous discharge with negative wires below the critical pressure. (3) The curves of critical intensity for the positive corona and wire diam. at various pressures are similar in form to those given by Peek's equation. (4) The ratio of the critical voltages for the positive and negative coronas on a given wire varies with the pressure. A pressure exists at which the two critical voltages are equal; below this pressure the negative critical voltage is lower than the positive; at higher pressures the positive corona-forming voltage is the lower. (5) The corona rectifies an alternating current, the direction of the rectified current depending on the voltage and the pressure. (6) In the case of the smallest wire an ionisation current flows before the appearance of the luminous discharge. I. W.

898. *The Induction Coil Spark.* **W. C. Baker.** (Phys. Rev. 5. pp. 68–71, Jan., 1915.)—The spark following the make of the primary current of an induction coil is composed of a series of discharges; and similarly at break. These are usually assumed to be oscillations in the secondary circuit consequent upon the single impulse due to the rise or to the fall of the current in the primary. The observations made by the author show that, in certain coils, at least, these partial sparks are not oscillatory, but in each case consist of groups of unidirectional pulses. Experiments were made with an induction coil capable of producing a 40-cm. spark. It was worked from a 110-volt circuit through a variable resistance.

With a 15-cm. spark coil the same phenomena were observed on a smaller scale. J. J. S.

899. *Condensation Nuclei produced in Gases by Ultra-violet Light.* **[Miss] M. Saltmarsh.** (Phys. Soc., Proc. 27. pp. 357–369; Disc., 369–370, June, 1915.)—(1) Nuclei produced in air by ultra-violet light which has traversed a few cm. of air are not affected by an electric field of 50 volts/cm. (2) The nuclei are equally effective in producing condensation of water, toluol, and turpentine vapours, and they are formed even by light which has traversed 50 cm. of air. (3) Alcohol vapour condenses without expansion on much smaller nuclei than does water-vapour. (4) No nuclei were formed by the light unless oxygen or CO_2 was present in the gas. (5) No trace of H_2O_2

could be detected in the clouds formed on the nuclei. (6) Oxygen containing ozone also contains nuclei for condensation, and these nuclei have similar properties to those formed by ultra-violet light. (7) The nuclei can be destroyed by heating the air containing them.

It seems probable that the nuclei formed by ultra-violet light do not cause condensation by virtue of any particular chemical composition, but that they are particles large enough to act like dust particles as centres round which condensation can begin. AUTHOR.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

900. *Light Sensibility of Selenium and Stibnite.* **D. S. Elliott.** (Phys. Rev. 5. pp. 58–64, Jan., 1915.)—An investigation was made of the behaviour of Se at liquid-air temperature and a special form of cell was devised, adapted for work at low temperatures. Stibnite was examined at 20° C. and —190° C., and its behaviour compared with that of Se. Sensibility curves of Se and stibnite at 20° C. and —190° C. show that lowering the temperature causes (1) a shift of the sensibility maximum towards the region of shorter wave-lengths by about 600 Å.U. for both stibnite and selenium, and (2) an extension of range of sensibility in both substances from $0{\cdot}9\,\mu$ to at least $2\,\mu$. Comparison of equilibrium exposures and exposures of 10 secs. for the same stibnite cell show a shift towards longer wave-lengths for the equilibrium exposures. As regards the law connecting deflections and energy: for equilibrium exposures both stibnite and Se obey the square-root law—*i.e.* $D = KE^{\beta}$, where $\beta = 0{\cdot}5$ approximately. For stibnite at —190° C., exposure 10 secs., $\beta = 0{\cdot}77$. Both Se and stibnite show voltage effects. The results obtained seem to indicate that the mechanism which brings about light sensitiveness in Se and stibnite is of the same general character. J. J. S.

901. *Wave-length Sensibility Curves for Crystals of Selenium.* **L. P. Sieg** and **F. C. Brown.** (Phys. Rev. 5. pp. 65–67, Jan., 1915.)—As an addendum to their previous paper the authors describe further experiments with a brighter source of light, which have enabled them to extend their observations to shorter wave-lengths—to $0{\cdot}38\,\mu$—and to prove that towards the ultra-violet the light sensibility goes on increasing. J. J. S.

902. *Nature of Electrical Conduction in Selenium.* **F. C. Brown.** (Phys. Rev. 5. pp. 395–403, May, 1915.)—The author propounds a theory of electrical conduction in selenium which resembles J. J. Thomson's "doublet" theory. Under illumination the electrons are supposed to be unstable or free, but on the average they recombine with the atomic structures very rapidly. Experiment shows that following intense illumination 80 % of the extra electrons return to their fixed positions in 0·02 sec. A second assumption is that the recombination of the freed electrons will take place according to the law of recombination of ions in gases. It is first shown experimentally that the electrons do recombine rapidly according to the above law. A common explanation accounts both for the variations from Ohm's law and for the large changes of conductivity accompanying pressure-changes. In each case the coefficient of recombination is found to vary inversely as the variable conductivity imposed by the pressure-change or the p.d. There is also common evidence that the rate of production of conducting electrons by a fixed illumination is directly proportional to the variable conductivity imposed by pressure or voltage. The fact that the pressure action is not transmitted beyond the region of stress can be explained. The transmitted light action is regarded as being of the nature of a crystal disturbance, which lowers the stability of the electrons everywhere in the confines of the crystal. I. W.

903. *Nature of Transmitted Light-action in Selenium.* **F. C. Brown.** (Phys. Rev. 5. pp. 404–411, May, 1915.)—The author has previously shown that light falling on one part of a crystal of Se will produce a change of conductivity throughout the crystal. He now (1) describes an experimental method of measuring the rate of transmission of the light-effect through the crystal, and (2) discusses the relation of pressure-effect to transmitted light-action. The transmitted action has a velocity which $\nless$ 2 cm./sec. ; hence it is concluded that the effect transmitted is not a temperature disturbance. The effects due to change of pressure and change of p.d. are not transmitted. The author concludes that electrical conduction in crystals of metallic Se cannot be due to the traditional free electron. The fact that Ohm's law does not hold is against the free-electron hypothesis. The most reasonable explanation is that which rests upon conduction by electrons in semi-stable equilibrium. Scattered throughout the crystal structure are centres, perhaps atomic centres, in which are associated charges of electricity in almost unstable equilibrium. Electrical conduction consists essentially of a pulling out of these electrons from their moorings in the direction of the electrical stress. I. W.

904. *Electrical Conductivity in Anisotropic Fluids.* **T. Svedberg.** (Ann. d. Physik, 44. 8. pp. 1121–1150, Aug. 4, 1914.)—Three substances, *p*-azoxyanisol, *p*-azoxyphenetol, and anisaldazine, were rendered conducting by the addition (1) of a trace of hydrogen chloride or (2) of the calcium salt to *α*-dinitronaphthol. The conductivity was measured when the anisotropic fluid was under the influence of electrical and magnetic fields acting in various directions relatively to the lines of flow of the current. In a typical case the conductivity was 37 % greater when a magnetic field was acting along the lines of flow of the current than when the magnetic field was transverse; when the angle of intersection was changed gradually the conductivities varied according to the law given by a rotation-ellipsoid with axes in the ratio 1·37 : 1·00, exactly as in the case of the thermal conductivity of uniaxial crystals. The ratio is larger with strong magnetic fields and increases when the temperature is lowered ; the highest ratios recorded are between 1·6 and 1·7. If one electrolyte is taken as a standard, the *relative* value for the other is independent of the temperature, of the strength of the magnetic field and of the nature of the anisotropic solvent. Similar effects are produced by strong electric fields, the natural conductivity of the liquid being increased 22 % by a longitudinal field of 1000 volts/cm. Capillary forces had no effect at a thickness of 0·5 mm., but in a film of thickness 0·05 mm. the conductivities in two perpendicular directions were in the ratio 1·4271 : 1. All these observations can be interpreted in terms of Bose's "swarm theory" of anisotropic fluids. T. M. L.

905. *Electrical Conductivity of Powders in Thin Layers.* **J. A. McClelland** and **J. J. Dowling.** (Roy. Irish Acad., Proc. 32. No. 5. pp. 51–58, May, 1915.)—Various conducting powders were embedded in a thin layer of paraffin wax and their conductivities measured before and after the application of an electric field perpendicular to the surface of the layer. Large increases of conductivity were observed. This increased conductivity is not

always destroyed by tapping, as in the case of the coherer. In a dry atmosphere it decreases exponentially with the time. With repeated applications and removals of the transverse field the conductivity reaches a maximum. The magnitudes of the transverse fields were of the order 100 to 800 volts. When the field is applied in steps instead of suddenly, no increase of conductivity is observed. The investigation is still proceeding, but meanwhile the authors suggest that possibly the grains of powder are surrounded by conducting films which do not extend from grain to grain, and that the conductivity is due to the electrons drawn across the intervening narrow spaces by the electric field. The application of the transverse field may cause the conducting films to spread so as to bridge over the gaps between the grains of powder. I. W.

906. *Electrical Conductivity and Pressure of Flow of Alloys of Potassium and Rubidium.* **N. S. Kurnakov** and **A. I. Nikitinski.** (Russian Phys. Chem. Soc., J. 46. pp. 860–871, 1914.)—The composition-electrical conductivity curve for mixtures of metals forming isomorphous mixtures in all proportions is a continuous curve exhibiting a minimum, the corresponding curve connecting the composition with the temperature-coefficient of resistance being symbatic in form. Consequently, at low temperatures the minimal conductivity for such mixtures should become more pronounced, and at high temperatures less so. The measurement of conductivity at high temperatures is, however, accompanied by considerable difficulty, and few results have been obtained in this direction. This difficulty is avoided in the author's measurements on K-Rb alloys, which fuse at low temperatures. The conductivity was measured at various temperatures from 0° to 100° with both liquid and solid alloys of different compositions. The alloys were prepared, and the measurements made in an atmosphere of nitrogen in special forms of apparatus.

At 0° and at 25° the conductivity curves show very flat minima at 73·11 and 80·57 atomic % Rb respectively, rise of temperature thus displacing the minimum towards the conductivity of the component with the lesser conductivity. The curves at 50–100° for the liquid alloys possess no minima, the conductivity increasing continuously from that of Rb to that of K. The curves for the solid alloys resemble those usually obtained for liquid solutions, owing to the slight lowering in the conductivity produced by adding K to Rb, 19·43 atomic % of the former metal changing $k_0 \times 10^4$ only from 8·86 to 8·6. The temperature-coefficients of resistance curves are similar to those of conductivity.

Addition of Rb to K is accompanied by a sharp rise in the pressure of flow at 22° from 0·09 to a maximum of 0·28 kg./mm.^{2} with 14·29 atomic % Rb, after which a continuous fall takes place to the value 0·08 for the latter metal. The curve is thus antibatic to those of conductivity and temperature-coefficient of resistance. It is evident that the pressure of flow is more sensitive than the electrical conductivity as an indicator of those changes which accompany the formation of isomorphous mixtures of plastic substances.

T. H. P.

907. *Electric Conductivity of Thin Films of Metal.* **A. Riede.** (Ann. d. Physik, 45. 6. pp. 881–912, Nov. 3, 1914. Extract from Dissertation, Göttingen, 1914.)—Thin films of Ag and Pt are chemically deposited, and thin films of Cu, Ni, and Pt are obtained by kathode discharge; they present phenomena of discontinuity as the thickness grows, as if the deposit at first consisted of scattered nuclei only, and these must be enlarged by accretion until at a particular stage we suddenly have a continuous conductor. Changes of this order—*e.g.* the passage from a finely-crystallised to a coarsely-crystallised state—account for a range of variations and critical points in the conductivity of metal films. A. D.

908. *Electrical Conductivity of Mixtures of Fused Salts.* **C. Sandonnini.** (Accad. Lincei, Atti, 24. pp. 616–621, April 19, 1915.)—The conductivities of fused mixtures of the following salts in different proportions have been measured: $PbCl_2$—$PbBr_2$; AgCl—AgBr and TlCl—AgCl. In all cases the conductivities found are less than those calculated from the law of mixtures, but in the first two cases the differences are small, whereas in the third they rise to more than 25 per cent. T. H. P.

909. *Electrical Conductivity of Vapours above* 1500° *C.* **E. F. Northrup.** (Science, 41. p. 804, May 28, 1915. Abstract of paper read before the Am. Assoc. for Advancement of Science.)—A furnace is described which gives safely a temperature above the melting-point of Pt and which will maintain a temperature above the melting-point of nickel for at least 140 hours. The furnace can then have its life renewed by the introduction of a new heater-unit. It is shown that at normal pressure the conduction is large and that it depends upon the form and material of the containing vessel and upon the frequency when alternating current is used: tables and curves are given in the original paper. The conductivity is unilateral. The author considers that 24 % of the conductivity of pure aluminium oxide at a temperature of about 1530° C. is due to the conductivity of the gas in its pores. I. W.

910. *Thermoelectric Behaviour of Metals on Melting.* **K. Siebel.** (Ann. d. Physik, 45. 6. pp. 839–860, Nov. 3, 1914. Abstract of Dissertation, Kiel.)—Various metals were compared with a fixed metal (constantan) whilst the hot junction was raised to different temperatures below and above the melting-point. It was found, in general, that with the metals used differing very much in characteristics there was an effect, though often only small, on the thermoelectric power when melting occurred. An irregularity in the thermo-curve takes place before and after the melting-point. The quantity dE/dT fluctuates irregularly between two or more relatively large values. This phenomenon occurs with all metals. Latent heat has an action upon the thermoelectric behaviour on melting. On examining the curves it was noticed that frequently the upper portion is shifted to a certain extent with reference to the lower at the melting-point: in some cases the upper portion remains parallel to the lower, in others a change of direction occurs. Small crystals may be formed on the solidification of a liquid metal and the thermo-e.m.f. is dependent in a high degree on the orientation of the crystals. J. J. S.

911. *Microstructure of Base-metal Thermo-couples.* **O. L. Kowalke.** (Am. Electrochem. Soc., Trans. 26. pp. 199–202; Disc., 213–214, 1914.)—In a previous paper it was shown that some thermo-couples of base metals retained a reasonably constant calibration during a series of tests, while others did not. It seemed probable that changes in the structure of the metal due to heat treatments may have occurred, or that high temperatures might have produced heterogeneity in certain alloys. The investigation here described had for object the establishment of relations between the microstructures of the wires of the couples and their calibrations under various conditions of test. Five separate samples about ½ in. long were cut from each of the wires of the couples. Sections of each set of samples were prepared for microscopic examination to show the original structure and that following a 2-hour treatment at 400°, 600°, 800°, and 1000° C., respectively. After heating in a furnace and cooling the samples were polished to a mirror surface on a section perpendicular to the axis of the wire. The samples were first examined to determine whether any structure was brought out by polishing, as would be the case with a mixture of hard and soft metals. Various etching agents were then tried. Photomicrographs illustrating the structure in the various samples are given in plates attached to the paper. The results obtained indicate that those metals which form solutions with one another give the best results, provided that the thermoelectric force is satisfactory and the melting-point high. Silicon does not appear to be a desirable constituent in a nickel alloy for thermo-couple material. Any segregation of the metal has an undesirable effect on the constancy of the couple. Wires containing but one metal showed a satisfactory structure. J. J. S.

912. *Thermal E.M.F.'s of Iron and Copper Oxides.* **S. L. Brown** and **L. O. Shuddemagen.** (Phys. Rev. 5. pp. 385–389, May, 1915.)—The authors have measured the thermal e.m.f.'s of Cu—CuO, Cu—Cu_2O, Cu—Fe_3O_4, Fe—Fe_3O_4, Fe—Cu_2O, and Cu_2O—Fe_3O_4 over a range of 600 or 700 deg. C. The oxides were prepared either by complete oxidation of metallic wires or by melting the oxide and moulding it into a solid rod. The solid rods of Cu_2O and Fe_3O_4 were 5 to 15 cm. long and nearly 1 cm. in diam. Temperatures were measured by a Pt and Pt-Rh couple.

The author's values are higher than those of previous observers. I. W.

913. *Pyro- and Piezo-electricity.* **W. C. Röntgen.** (Ann. d. Physik, 45. 5. pp. 737–800, Oct. 15, 1914.)—Investigations were carried out (1) on the connection of the pyroelectric constants of a tourmaline crystal with the temperature, (2) pyroelectric observations on other tourmaline crystals, (3) pyroelectric observations on quartz, (4) piezoelectric observations on various tourmalines. (5) The question of the existence of a true pyroelectricity is discussed. From the observations of J. and P. Curie there seems to be some ground for the conclusion that temperature changes bring on deformations in the crystals and that pyro-electricity may be reduced to piezo-electricity. The existence of a true pyro-electricity seems possible to the author on theoretical grounds, but further observations are required to establish its existence. J. J. S.

914. *Coefficients of Mutual Induction of Coaxial Coils.* **S. Butterworth.** (Phil. Mag. 29. pp. 578–592, April, 1915.)—The investigation supplies formulæ for the mutual induction of coils for which the ratio of the inner and outer diameters differs considerably from unity. The method adopted is to find the mutual induction between two mutually external semi-infinite coaxial coils having zero core diameters and unit winding density (*i.e.* the number of turns per unit area of channel section is unity), and then by applying the laws of combination of mutual inductances to find the mutual induction between finite hollow coils. The results are extended so as to include self-induction. F. E. S.

915. *Tables of Numerical Data in Electricity, Magnetism, and Electrochemistry* (pp. 258–417, Paris, 1914).—This is a reprint of the pages relating to the above subjects in the now well-known *Tables Annuelles de Constants et Données Numériques* (vol. 3, 1912). Other separate parts are also issued, dealing with the sections Spectroscopy, Radio-activity, and Metallurgy. Owing to this arrangement investigators need only acquire that section which is of interest to them. In the present issue the matter is grouped under the following headings:—Electrical conductivities and resistances; Thermo-e.m.f.'s; Dielectric constants; Sparking potentials, electric strengths, etc.; Electric waves, photo-electricity, etc.; Ferro-magnetism; Hysteresis; Magneto-chemistry; Magnetic rotation, Kerr and Hall effects; Conductivity of electrolytes; Electromotive forces. L. H. W.

916. *Self-induction of Solenoids of Appreciable Winding Depths.* **S. Butterworth.** (Phys. Soc., Proc. 27. pp. 371–388, June, 1915.)—The existing formulæ for coils of this type—viz. those of Rosa and Cohen—are shown to be inaccurate, the error amounting to one-fifth of 1 per cent. for the best formula when the winding depth is one-tenth the diameter of the coil. For greater winding depths the error is larger. The inaccuracy in Rosa formula is due to the neglect of curvature in correcting for thickness, while in Cohen's formula the error is due to the approximate method of development.

New formulæ are developed by methods which are free from such approximations, and which apply to any coil for which the length is greater than twice the diameter, and the winding depth is less than one-tenth the diameter. These formulæ are capable of giving eight-figure accuracy.

Simplified formulæ are also given which are suitable when only four-figure accuracy is required. AUTHOR.

917. *Precision Resistance Measurements with Simple Apparatus.* **E. H. Rayner.** (Phys. Soc., Proc. 27. pp, 384–405; Disc., 406–409, June, 1915.)—Describes methods by which the comparison of resistances can be made to an accuracy of 1 in 10,000 or higher by using simple apparatus usually available in electrical laboratories, or which can be easily constructed with little skilled assistance.

The comparison of nominally equal resistances of 1 ohm and upwards by the usual method of shunting one side of a nearly balanced quadrilateral by a high resistance is mentioned, and variations on this when only part of one resistance is shunted are often useful. The great advantages of having resistances capable of carrying comparatively large currents is illustrated, especially for measuring changes of resistance of commercial apparatus under working conditions. The determination of errors in a volt box for use with a potentiometer is described at some length. This is of especial importance in precision photometry.

If a sufficient continuous-current voltage is not available for testing such apparatus as high-potential dividers, it is shown that using sufficient continuous current to secure sensitivity the heating may be supplied by superposed alternating current.

Resistances in common use are very generally of simple numerical value, and a Kelvin bridge specially designed for the comparison of such resistances is described. It consists essentially of two rows of 25 resistances of 20 ohms each. AUTHOR.

918. *An Instrument for the Optical Delineation and Projection of Physical Curves.* **J. A. Fleming.** (Phys. Soc., Proc. 27. pp. 316–325; Disc., 326–327, June, 1915.)—This instrument is designed for projecting on to a screen or photographing on a plate such curves as magnetic hysteresis, resonance,

or characteristic curves which can be performed slowly, or are non-periodic or non-repetitive. It consists of a base board on which is fixed a thin wooden ring wound over with one layer in close turns of insulated Eureka wire. The insulation on the top surface is removed so as to expose the wire. At the centre of the ring there is a pivot which carries a radial arm, the end of which rubs on the bare Eureka wire. The ends of the Eureka wire are connected to a battery of *n* cells and the middle point of the wire is connected to a terminal, and also the centre of the radial arm to another terminal. The arrangement forms a circular potentiometer so that any required fraction of the battery voltage can be produced in either direction between the last-mentioned two terminals. On the same base there is a rectangular mirror slung on a longitudinal axis, which mirror is tilted by a thread wound round the shaft of the radial arm of the potentiometer. Hence, if a ray of light from a mirror magnetometer or galvanometer is reflected to the tilting mirror and thence on to another fixed mirror with its axis at right angles to that of the other and then to a screen, the spot of light will have two motions, one a horizontal one proportional to the displacement of the radial arm, and, therefore, to the p.d. of the two terminals, and another vertical motion proportional to the deflection of the galvanometer or magnetometer. If, then, we place behind the magnetometer a long coil having a long iron wire within it and send a current through this coil which is supplied from the potentiometer travelling terminals, the spot of light will be actuated by two motions, one a horizontal one proportional to the magnetising force, and the other a vertical one proportional to the central flux density in the iron. It will, therefore, describe a hysteresis curve when the radial arm is moved to and fro cyclically through a certain arc or angle. In the same manner the instrument can be used to delineate characteristic curves of wireless detectors or rectifiers or other devices. By using a rotating condenser of variable capacity in place of the circular potentiometer, the instrument can be used for delineating resonance curves of wireless telegraph plants. AUTHOR.

ALTERNATING CURRENTS AND MAGNETISM.

919. *Nature of the Ultimate Magnetic Particle.* **K. T. Compton** and **E. A. Trousdale.** (Science, 41. p. 611, April 23, 1915. Phys. Rev. 5. pp. 315–318, April, 1915.)—As a means of deciding between the molecular and the electron theory of magnetism, X-ray photographs were taken through crystals of magnetite, hematite, and pyrrhotite in the magnetised and unmagnetised states. The experimental results with the first two crystals indicate that the atoms do not leave their positions of equilibrium during magnetisation. These results are consistent with the electron theory of magnetism, and prove that magnetism is not a molecular phenomenon. G. E. A.

920. *Study of Heterogeneous Magnetic Fields by Means of the Zeeman-effect.* **H. Nagaoka** and **T. Takamine.** (Math. Phys. Soc. Tōkyō, Proc. 8. pp. 73–79, March–April, 1915.)—The examination of magnetic fields by means of the Zeeman-effect opens up a new method of investigation which is free from most of the objections inherent to the use of a search coil and a ballistic galvanometer or of a bismuth spiral. With the search coil, which has necessarily a finite area, the variation of the field cannot be followed from point to point, and in the use of the Bi spiral, whose area, again, is generally larger than that of the search coil, the resistance is sensitive to changes of tempera-

ture. By using a vacuum tube of small bore (radius about 0·8 mm.) between the pole-pieces, and employing instruments of high resolving power, we can obtain a photogram of the line which represents the distribution of the field from point to point. The separation is generally proportional to the strength of the field, and if the constant for the separation of the line is known the gradient of the field can be easily obtained. The vacuum tube must always be placed either parallel or perpendicular to the field, whose direction must previously be determined. The Hg green line is suitable for the purpose, as it is divided into a nonet, with lines at frequent intervals, and is very strong. The Hg violet line $\lambda 4047$, which is divided into a triplet with separation double of the normal, is very convenient for photographing, but as the visual observation is rather difficult, the focusing of the instrument is troublesome. Tubes of helium or neon are sometimes preferable in weak fields, as the lines are usually sharp; but in strong fields it is difficult to run the current through the tube without the risk of cracking it. Graphs are given for two of the pole-pieces employed, and show that as the magnetisation approaches saturation the field gradient becomes gradually less steep, and the increase of the field H with that of the magnetising current smaller, so that the product $H dH/dx$ (where x is measured at right angles to the axis of the magnet) does not generally increase with the current. For experiments with the Zeeman-effect in heterogeneous fields wedge-shaped pole-pieces are to be recommended. [See Abs. 867, 1889 (1914).] A. W.

921. *Criterion of Steel suitable for Permanent Magnets.* **S. P. Thompson.** (Phys. Soc., Proc. 27. pp. 179–185, April, 1915. Electrician, 75. pp. 65–66, April 16, 1915.)—Setting aside the question of form, the first requisites of a steel for permanent magnets are large remanent magnetism (I_r) and high coercive force (H_c), that material being the best for which the product of these two quantities is the highest. It has been recently suggested that the ratio of the two quantities should be taken as the criterion required, and tables of the product and ratio for a number of substances are employed to show that the use of the ratio leads to absurd results. In the *discussion*, **S. W. J. Smith** considered that if constancy of the moment were in question, the ratio might be more valuable as a criterion. **Chree** drew attention to the importance of constancy of distribution of magnetism. **E. H. Rayner** proposed a figure of merit of the form $(I_r - 400)(H_c - 20)$, so that those materials which gave a negative figure would be considered worthless. **J. R. Ashworth** pointed out that it was the ratio which showed that hardened iron is more suitable for a stable magnet than soft iron, and, further, that the case of terra-cotta is favourable to the view that a high ratio is indicative of high permanence. The product and the ratio are not rival expressions for the same thing, but represent different quantities. G. E. A.

922. *Magnetic Susceptibility and Electrolytic Dissociation.* **A. Quartaroli.** (Gazzetta Soc. Chim. Ital. 44. 2. pp. 43–63, 1914.)—The method previously described [Abs. 1740 (1914)] has been applied to the study of the magnetic susceptibility of a number of solutions of iron, manganese, nickel, and cobalt salts, either alone or in the presence of mannitol or ammonium chloride, citrate, or tartrate.

The results show that, although an undeniable relation exists between electrolytic dissociation and magnetic susceptibility, the latter does not depend merely on the free ions of the magnetic elements. Where complex ions are present, the susceptibility may be even greater than with the simple salts. Additional support is thus afforded by the general rule that the contribution of atoms to the physical constants of compounds is a variable dependent on the other atoms present, and probably also on the order of arrangement. T. H. P.

923. *Thermomagnetic Properties of Various Compounds at Low Temperatures.* **T. Ishiwara.** (Tôhoku Univ., Sci. Reports, 3. pp. 303–319, Dec., 1914.)—The author has made a number of measurements at low temperatures by the methods previously employed [Abs. 350, 351 (1915)], a copper-constantan thermocouple being used in place of one of Pt—Pt-Rh. The large volume of numerical results obtained leads to the following conclusions:—

At low temperatures the diamagnetic susceptibilities of the organic and inorganic compounds examined remain fairly constant in the same physical states. That of liquid ethyl alcohol is rather less than that of the solid, a slight discontinuous change occurring during fusion. That of methyl alcohol is nearly the same in the liquid and solid states, but a pit occurs in the susceptibility-temperature curve at the melting-point. Liquid ethyl acetate has a somewhat greater susceptibility than the solid, but with glycerine there is constancy throughout. Solid benzene also shows constant susceptibility, but a slight increase accompanies melting; Oxley [Abs. 495 (1915)] found only a small pit in the χ-t curve. The susceptibility of toluene remains nearly constant, there being a slight pit at the melting-point; Oxley found a small increase on fusion. That of pure water is constant in either the liquid or the solid state, a minute increase accompanying melting; Curie ("Œuvres," p. 232, 1908) found no such discontinuity. The diamagnetic susceptibilities of inorganic compounds are all constant throughout the range of temperatures employed.

The paramagnetic susceptibilities of inorganic compounds vary slightly with temperature. In $KMnO_4$ it is constant, but in CuO and $CuBr_2$ it increases, and in $FeF_3, 3H_2O$, it decreases slightly as the temperature rises, the latter being the more general behaviour. Of 23 compounds, 5 satisfy Curie's law moderately well, and 12 obey the relation, $\chi(T + \Delta) = \text{const.}$, in which Δ is a positive or negative constant, but the range of temperature was only about 200 deg., and it is not certain that this rule would hold up to a very high temperature. For the remaining 6 compounds the $1/\chi$-t curves deviate from straight lines even for the temperature interval used. T. H. P.

924. *Some Deductions from the Theory of the Hall-effect.* **G. T. Bordonaro.** (Accad. Lincei, Atti, 24. pp. 336–341, March 12, 1915.)—The author tests the principle of reciprocity in connection with the Hall-effect, which principle would follow from the work of Corbino and of Volterra. This principle is, "that if a current be passed from a point A′ to another B′ through a lamina situated in a magnetic field, there will be a certain difference of potential between two other points A and B, and when the same current be passed from A to B, then provided the magnetic field be reversed, there will be between A′ and B′ the same p.d. that there was in the first case between A and B." This was tested with a disc in a field of 6000 gauss and a current 0·2 amp., and was found to be true. The author also points out the necessity for using point potential-contacts in measuring the Hall-effect, and the errors introduced by using strips along an edge of the conductor for such contacts. S. G. S.

925. *Difference between the Magnetic Diurnal Variations on Ordinary and Quiet Days at Kew.* **C. Chree.** (Roy. Soc., Proc. 91. pp. 370–381, June, 1915.)—The paper contains the results of an investigation into the nature of the

diurnal inequality of the magnetic elements at Kew, whereby the author has discovered a somewhat remarkable relationship between the inequalities derived respectively from quiet days and from ordinary days. The diurnal variation in the horizontal components of magnetic force has been advantageously studied by considering the vector which represents the force to whose action the departure from the mean value for the day may be ascribed. Vector diagrams are given in the paper, and it is found that the difference vector lines, instead of being oriented promiscuously, show a marked approach to a common direction. Also a remarkable feature was that the diurnal variation in days of any kind consists not merely of a periodic, but also of a non-periodic part, the existence of the latter being evidenced by the n.c. (non-cyclic) change, *i.e.* the excess of the value at the second midnight over that at the first midnight of the representative day. The apparent n.c. change in any element is composed of several parts. In addition to the secular change, and any true n.c. change characteristic of the particular type of day, there is in general an instrumental contribution. It has been found that the difference between the normal ordinary and quiet day diurnal variations in the horizontal plane consists, to a first approximation, of an oscillation of 24-hour period, along a line inclined 64° to east of north, and of a change proceeding at a uniform rate throughout the 24 hours along a second line perpendicular to the first. It is difficult to say whether the ordinary- or the quiet-day inequality has the greater claim to be regarded as the fundamental, the former being of a much more hybrid character than the latter. The main phenomenon of the n.c. change in quiet days at Kew, viz. the large increase in H, has been observed at other places. This suggests the probability that phenomena analogous to those here described may prove to hold good elsewhere. If this should be the case, the fundamental lines to which the phenomena are attached are presumably related in some way to some fundamental direction connected with the earth's magnetism. It is thus a suggestive fact that the vertical plane at Kew inclined at 26° to west of north comes at least near to containing the earth's north magnetic pole.

H. H. Ho.

926. *Magnetic Oxide of Chromium.* **T. Soné** and **T. Ishiwara.** (Tôhoku Univ., Sci. Reports, 3. pp. 271–275, Dec., 1914.)—The magnetic compound was obtained from chromyl chloride by a process of distillation, a grey-black deposit being formed in a metre-long tube attached to the retort and kept at 400° C. The tube was cut into pieces, the coatings of powder removed and put into thin glass tubes 10 cm. long, the specimens thus obtained being tested by the magnetometric method. The largest value of I obtained was 30 in a field of 360 gauss, and the smallest was 8. The susceptibility values are about 10 times as large as those obtained by Shukoff [see Abs. 1484 (1908)]. The specimen was heated in air at 1000° C. and from the loss of weight observed it was concluded that the strongly magnetic specimen was composed chiefly of the magnetic compound Cr_5O_9. The critical temperature was found to be about 150° C.

G. E. A.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

927. *The Use of the Röntgen Rays in Palæontology.* **R. M. Field.** (Am. J. Sci. 39. pp. 543–550, May, 1915.)—In the author's preliminary experiments it was discovered that a pencil of rays having an intensity of 6 Benoist could easily penetrate specimens of such rocks as shale, sandstone, and limestone at

least 2 cm. thick. It was also found upon examining the skiagraphs that the surface inequalities of the specimens had been faithfully reproduced. This discovery led to experiments with rocks which bore merely the print of an organism, such as the moulds of striated brachiopods and of the cephalon and pleura of trilobites in a sandstone. As had been expected from the first experiment, the resulting skiagraphs showed the surface details almost as clearly as if they had been photographed. Having determined that the ray would penetrate and record upon the X-ray plate the graphs of the common sedimentary rocks up to at least 2 cm. in thickness, the next problem was to determine if the X-ray would bring out on the X-ray plate some petrified organism which was partially exposed on the surface of a sedimentary rock. Experiment shows that that portion of the fossil which remains hidden will be registered when the fossil is composed of a substance whose density is greater or less than that of the matrix in which it lies.

The best results are obtained by studying the original skiagraph as shown in the exposed and developed X-ray plate, for even a print loses greatly in detail. A plate is given showing 11 reproductions of the fossils examined.

L. H. W.

928. *Radioscopic Method of Determining the Depth of a Foreign Body.* **Hirtz and Gallot.** (Comptes Rendus, 160. pp. 489–490, April 12, 1915.)—The special apparatus required is a small radioscopic screen (*e.g.* 8 × 12 cm.) with a hole through its centre. The patient is placed on the table, the Röntgen tube being below. The normal ray passing by the projectile, the screen is so arranged that the shadow of the foreign body falls at its centre O. The position O is marked on the skin with a dermographic pencil. The tube is next displaced in the horizontal plane in any direction, and the new position O_1 of the shadow on the screen is noted. A special apparatus allows the screen to be raised and again lowered into exactly the same position : while the screen is raised the patient is removed from the table. The screen being again in position and the tube still in its last position, a small ball of lead attached to a thread is lowered through the hole in the screen. When the tube is working the height of this lead is altered until its shadow falls exactly at point O_1 on the screen. The distance from the edge of the screen to the centre of the ball is then the depth of the projectile in the body.

A. E. G.

929. *Radioscopic Method of Localising Projectiles.* **Viallet** and **Dauvillier.** (Comptes Rendus, 160. pp. 562–565, April 26, 1915.)—The method described is rapid, free from danger, and enables the projectile to be located to about 1 mm. It is based on the principle of triangulation, and consists essentially in ascertaining the displacement of the shadow of the foreign body on the screen for two successive positions of the bulb. An arrangement, which is described in detail, increases the distinctness of the shadow, and thus allows of a greater precision ; at the same time it resolves mechanically the greater part of the equation connecting the distance of the foreign body from the screen with the movements of the shadow and the tube. A. E. G.

930. *Radio-therapy : Its Scientific Basis and its Teaching.* **J. Joly.** (Roy. Dublin Soc., Proc. 14. No. 37. pp. 491–512, April, 1915.)—This contribution is based on a paper read to the Dublin Clinical Club in March, 1915. The paper commences with an historical survey of recent work on ionisation produced by X-rays and γ-rays, a summary of the leading facts obtained in the work on photoelectric effects being also given. Reference is next made to the β- and

γ-radiations given out by radio-active bodies, Rutherford's theory of these rays being indicated briefly. The influence of the electrons in bringing about chemical changes is dealt with, and the effect of X-rays and γ-rays on the living cell studied. In these radiations physicists possess a subtle means of attacking the mechanism of cell growth. The work of Moseley and Robinson, who determined the relative ionisation of β- and γ-rays, is reviewed and their results are applied to therapeutic questions.

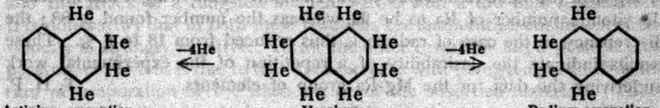
The second, and more important, part of the paper is devoted to the consideration of photo-sensitive systems. After discussing the point that photographs are effects of photoelectric activity, and showing that the latent-image formation by radiation is not a chemical (*i.e.* molecular) action, the author gives the principal methods by which the latent image may be formed. The formation of the latent image in an ordinary photographic plate by chemical means is first treated, the action of an alkaline solution of gallic acid being taken as one example. Referring now to the living cell, it is shown how radiation may, if carefully modulated, stimulate, and, if too intense, retard the growth and ultimately destroy the molecular structure required for mitosis. The effects on the growth of the cell—superficially at least—resemble those on the formation of the latent image. It is also found—and the whole efficacy of radio-active treatment turns upon this—that in the case of the pathological these phenomena appear all in advance of the like effect in the normal cell. The author clearly shows that a very complete parallel exists between the effects of radio-active and mechanical stimuli in both cases—the latent image and the cell. There seems to be no doubt that the growth of the cell is highly sensitive to ionic concentration. In this light the abnormal lowering of acidity in the digestive secretions of cancerous patients is discussed. The facts advanced suggest that the antagonistic action of the acid and the alkali in the cell is parallel with the antagonistic action of restrainer and sensitiser upon the film. An explanation is suggested of the injurious effects of tobacco smoking and the apparent limitation of cancer of the tongue, lip, and throat to the male sex. Tannin or gallotannic acid, itself a photographic sensitiser, is considered a far more injurious substance in this connection. The cancer statistics, when compared with the statistics for the consumption of tea in this country, show common features. These views have led the author to seek for the cause of the increase of cancer in the increased consumption of such articles of diet, notably tannin, as may introduce sensitising substances into the system.

Reverting to the theory of radio-therapy, the author infers that in radio-active treatment we effect ionic changes in the cell which are equivalent to increasing the amount of sensitiser present. But the cancer cell has already within it almost the limiting amount of the sensitiser which its continued metabolism permits. The result of radio-active treatment is to overstep this limit and bring the amount of sensitiser up to the lethal concentration.

The use of small multiple centres of radiation, the effects of which are more easily localised and rendered uniform, is preferable to strong centralised radiations where lethal effects are long surpassed in one region before the destructive dosage is reached in another. A. B. W.

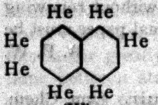
CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

931. *Molecular Structure of Radio-active Atoms.* **G. Oddo.** (Gazzetta Soc. Chim. Ital. 44. 1. pp. 219–235, 1914.)—In order to explain the loss of helium atoms during the disintegration of radio-active elements, the author suggests that these atoms are arranged in the form of one or two contiguous hexagons, in the same way as the carbon atoms of the benzene or naphthalene molecule. The uranium atom would thus contain 8 He-atoms in two hexagons, which must differ in some way one from the other, loss of 4 He-atoms occurring in two modes to yield ActEm and RaEm :—

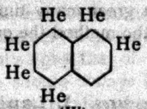


Actinium emanation. Uranium. Radium emanation.

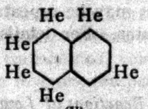
The loss of He from the α'-position would give an unknown term, which undergoes transformation into (III), representing uranium-2, whilst further loss of He would yield uranium-Y (IV), uranium-X (V), and ionium (VI), three, and only three, such isomerides being known :—



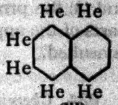
(III)



(IV)



(V)



(VI)

It is then shown that, with the elements constituting 86·5 % of the earth's crust, the differences of the atomic weights from multiples of 4 are not greater than 0·3. This may be mere coincidence, or it may be that non-radio-active atoms, or at least certain of them, are to be regarded as stable condensation terms of helium atoms. [Compare Collins, Abs. 1168 (1914).] T. H. P.

932. *Result of Plotting the Separation of Homologous Pairs against Atomic Numbers instead of Atomic Weights.* **H. E. Ives** and **O. Stuhlmann, Jr.** (Phys. Rev. 5. pp. 368–372, May, 1915.)—According to Runge and Precht [Abs. 1360 (1903)], in each group of chemically related elements the atomic weight varies as some power of the distance apart of the two lines of a spectral pair, so that the logarithms of the atomic weights are related linearly to the logarithms of these distances; this law applies only to homologous pairs of lines, these being characterised by similar behaviour in the magnetic field. With the group Mg, Ca, Sr, Ba, and Ra the above relation gives for the atomic weight of radium the extrapolated value 257·8, which differs by 13 % from that obtained by Mme. Curie by chemical methods. The fact that this is not the only exception detracts from the value of the law as a means of arriving at atomic weights [see Watts, Abs. 1641, 2552 (1904);

Rudorf, Abs. 346 (1905)]. Moseley [Abs. 467, 1249 (1914)] has shown that the most characteristic figure connected with a chemical element is not its atomic weight but its atomic number, which is identified with the charge on the positive nucleus of the Rutherford atom; not only are these atomic numbers integers, but their values for the elements are arranged in order according to the chemical properties, without the inversions found in the cases of Ni and Co, Ar and K, and Te and I, when atomic weights are considered. The authors have consequently plotted the logarithms of the atomic numbers against the logarithms of the distances apart of the two lines of a spectral pair. The results show that the exceptions to Runge and Precht's relation observed with boron, potassium, and the series of Zn, Cd, Hg, now fall into line. In the case of the series, Mg, Ca, Sr, Ba, Ra, the points for Ca, Sr, and Ba lie on a straight line, which does not pass exactly through the Mg point, the value 13 giving better results for the atomic value of Mg than the value 12 ascribed to this element. This straight line indicates the atomic number of Ra to be 96, whereas the number found is 88; the discrepancy in the case of radium is thus reduced from 18 to 8 %. These results indicate the desirability of a repetition of the experimental work underlying the data for the Mg-Ra group of elements. T. H. P.

933. *Extraction and Purification of Radium Emanation.* **W. Duane.** (Phys. Rev. 5. pp. 311–314, April, 1915.)—The general principles of the method are those previously employed by Ramsay and Soddy, Rutherford, and Debierne. The chief advantages of the method are: (1) the purification does not require liquid air, (2) a large number of millicuries of emanation can be purified and compressed into a small fraction of a mm.^{3} in 10 to 15 minutes, and (3) the process may be repeated a great many times without renewing parts of the apparatus. For details of the method the original paper must be consulted. A. B. W.

934. *Chemical Reactions at Low Pressures.* **I. Langmuir.** (Am. Chem. Soc., J. 37. pp. 1139–1167, May, 1915.)—The experiments made by the author during the past few years have shown that the filament of a lighted tungsten lamp will, under suitable conditions, cause the disappearance, or "clean-up," of almost any gas introduced into the bulb at low pressure, and that, in the great majority of cases, this action is purely chemical in nature. The arrangement employed consists of a bulb containing one or more short filaments of tungsten (or other metal) and sealed to an apparatus comprising essentially a mercury Gaede pump, a sensitive McLeod gauge, and a device for introducing small quantities of gases into the system and for analysing the residual gases. The pressure in the system can be lowered to 0·00002 mm. of Hg, the gauge giving a scale reading of 1 mm. for a pressure of 0·000007 mm. One cub. mm. of gas at atmospheric pressure suffices for the estimation of hydrogen, oxygen, CO_2, CO, nitrogen, and inert gases. Emphasis is laid on the fact that the use of gases at extremely low pressures simplifies the experimental conditions enormously, the velocity of the reaction being then far more intimately related to the behaviour of the individual molecule than is the case at higher pressures.

The reactions occurring when gases are cleared-up by a heated filament are of four distinct classes, in which: (1) the filament is attacked by the gas; (2) the gas reacts with the vapour given off by the filament; (3) the filament acts catalytically on the gas, producing in the latter a chemical change but not itself undergoing permanent change; (4) the gas is charged chemically or made to react with the filament by means of electrical discharges through the gas. These types are considered separately. In each case it is found that the velocity of the reaction is limited by the rate at which the reacting molecules come into contact with each other. With reactions occurring on the surface of the wire, only a small fraction of the surface is in a condition suitable for the reaction; in these cases the velocity of the reaction is limited by the rate at which the gas molecules can strike such part of the surface. In no instance is there any evidence indicating that the reaction is limited by any process of diffusion in the ordinary sense of the term. Where the gas combines with vapour from the filament the velocity is also limited by the rate at which contact between the molecules occurs, reaction invariably following contact. In only two cases has it been found possible to measure a reaction velocity not limited by such purely physical factors, these being the combination of nitrogen with Mo-vapour and the attack of a tungsten filament by CO with a low bulb temperature. It is noteworthy that in both these reactions the temperature-coefficient of the velocity is strongly negative. In all the other cases the large positive temperature-coefficient is due to the rapid increase with rising temperature of the rate of evaporation of the filaments or of the adsorbed materials. These results suggest that chemical reactions with negative temperature-coefficients of the velocity are very common and that the effects are masked by other factors of physical nature having high positive temperature-coefficients. Bodenstein cites the reaction, $2NO + O_2 = 2NO_2$, as one having a negative temperature-coefficient, and Strutt found that atomic nitrogen recombines to form molecules far more rapidly at low than at high temperatures, and he reasons that a high translational velocity of the molecule should, in general, hinder rather than hasten the reaction. Strutt considers further that rotational velocity of the molecules favours reaction, and that, with most reactions, this factor greatly outweighs that of the translational velocity. Thus reactions between atoms should always have negative temperature-coefficients, since atoms cannot have rotational energy.

The author's results lend support to Strutt's views. T. H. P.

935. *The Allotropy of Bismuth.* II. **E. Cohen.** (K. Akad. Amsterdam, Proc. 17. pp. 1236–1238, June 3, 1915.)—From a further study of bismuth, the author concludes that this metal exists in more than two forms. The question of the limits of stability of these is under investigation. A. F.

936. *Metastability of the Metals in Consequence of Allotropy, and its Significance for Chemistry, Physics, and Technics.* IV. **E. Cohen** and **W. D. Helderman.** (K. Akad. Amsterdam, Proc. 17. pp. 1238–1241, June 3, 1915.)—The authors point out that since they have shown that cadmium and a number of other metals can exist in different allotropic forms, and since these forms can exist for some time owing to slowness of transformation of the metastable varieties, these metals, as ordinarily known, consist of mixtures in different proportions of the different allotropic forms. In consequence, the values of the heats of reaction with these metals and of the latent heat of fusion of the metals, hitherto determined, are indefinite, as it is not known with which variety of the metal, or with what mixture of forms, one was dealing. [A complete summary of the author's work on this subject is given in Rev. de Mét. 12. pp. 125–146, March, 1915, and Faraday Soc., Trans. 10. pp. 216–239, May, 1915.] A. F.

937. *Hardness and Modulus of Elasticity of Isomorphous Mixtures of Copper and Nickel.* **N. Kurnakov** and **J. Rapke.** (Russian Phys. Chem. Soc., J. 46. pp. 380–394, 1914.)—Maxwell's relaxation theory leads to the expression $\eta = ET$, where η is the coefficient of internal friction and is proportional to the pressure of flow [compare Kurnakov and Shemtschushni, Abs. 1780 (1914)], E the modulus of elasticity, and T the time of relaxation. Further, it has been found experimentally that the hardness, H, determined by Brinell's method, and the pressure of flow, are proportional to one another, so that η and H should also exhibit proportionality.

The authors have determined the hardness and modulus of elasticity of a series of alloys of Ni and Cu in various proportions. Addition of Ni to Cu is accompanied by a gradual increase of the hardness from 32 kg./mm.^{2} to a maximum of 81·3 kg./mm.^{2} for 47–50 % Ni, beyond which the hardness falls regularly to 62·8, the value for nickel. On the other hand, the modulus of elasticity, in kg./mm.^{2}, increases linearly from 11,110 for copper to 20,100 for nickel. Hence, the increase in the hardness and in the coefficient of internal friction for solid solutions showing a maximum of hardness does not depend on increase of the modulus of elasticity in the equation $\eta = ET$, but is related to increased time of relaxation. This conclusion is confirmed by observations made on a number of solid solutions of copper and iron, in which increased hardness corresponds with diminution of the modulus of elasticity; this is the case with brass, bronze, steel, and other alloys of technical importance. Further, it seems that alteration of "relaxation" hardness proceeds parallel with that of brittleness.

A second typical case, theoretically possible, is that in which increased hardness results from increase of the modulus of elasticity. Such substances would be of great industrial interest, as they would be very hard without exhibiting increased brittleness. Whether manganese, nickel, and other special steels belong to this class must be determined by further experiment.

T. H. P.

938. *New Researches on Copper-Zinc Alloys.* **L. Guillet.** (Rev. de Mét. 11. pp. 1094–1132, Oct., 1914.)—A series of copper-zinc alloys, containing from 0 to 44 % Zn has been prepared from the purest materials obtainable commercially. On this series a complete study has been made of the influence of composition and method of working on the mechanical properties. The relation existing between mechanical properties and structure of metals and alloys is discussed in a general way and descriptions of the equilibrium diagrams of the industrial copper alloys are given. Charpy's work indicates that the tensile strength of the alpha alloy increases only very slowly with increase of Zn, but that the ductility passes through a maximum at about 30 % Zn. Appearance of the beta constituent is marked by a rapid increase in the tensile strength, which attains a maximum at about 45 % Zn. In the other α-alloys of copper the mechanical properties are functions of composition, so that the behaviour of the Cu-Zn alloys is an anomalous one. The author's study of the tensile strength, ductility, hardness, and resilience confirms the existence of these anomalies at substantially the same compositions found by Charpy. The maximum in the tenacity curve corresponds to the appearance of fragility in the resilience test, while the maximum in the elongation coincides with the possible existence of the β constituent as shown by the equilibrium diagram. In the annealed alloys there is a direct linear relationship between the tenacity and the ball hardness. Other things being equal, cold work, which produces the highest

ductility, gives the lowest elastic limit. The method of rolling has a considerable influence on mechanical properties, but these influences are completely removed by annealing. Quenching produces a sensible increase in the ball hardness. For press work, the use of alloys containing at least 72 % of Cu is advised, such alloys being less likely to develop season cracks than alloys richer in zinc. F. C. A. H. L.

939. *Alloys of Mercury and Thallium.* **P. Pavlovitsch.** (Russian Phys. Chem. Soc., J., 47, pp. 29–46, 1914.)—The author has investigated the complete melting-point diagram of the system Hg-Tl, the electrical conductivity of the alloys containing 0–40 % of Tl, and the hardness, by Brinell's method, of the alloys containing 90–100 % of Tl.

Kurnakov and Pushin's supposition concerning the existence in the fusion diagram of an irrational maximum, not corresponding with simple atomic proportions of the constituent atoms, is confirmed; the composition at this maximum is 29–30 at. % Tl. The curve of conductivity shows a maximum at 26–28 at. % Tl, and the potential curve a re-entrant angle at 27–28·4 at. % Tl, both of these being also irrational points. In the absence from these curves of separate or, as Kurnakov styles them, singular or Dalton points, the α-phase in the system Hg-Tl resembles the γ-phase of the system Tl-Bi [compare Kurnakov, Shemtschushni, and Tararin].

This irrationality may be explained by the existence of the dissociating compound, Hg_3Tl, which forms with the components solid solutions within the limits 21–31 at. % Tl. According to Stepanov's rule, the magnitude of the temperature-coefficient of resistance, which approximates to that for pure metals (0·04), indicates the existence of a chemical compound in the α-phase. Within the limits 86–100 % of Tl, the latter forms with mercury β-solid solutions, characterised by enormously increased hardness. T. H. P.

940. *Are the Deformation Lines in Manganese Steel Twins or Slip-bands?* **H. M. Howe** and **A. G. Levy.** (Am. Inst. Mining Eng., Bull. No. 99. pp. 587–600, March, and pp. 1467–1468. July, 1915.)—On a polished surface of Hadfield's austenitic manganese steel, plastic deformation develops lines which look like slip-bands, but differ from them in that they persistently reappear after repolishing and etching, and also in that they become more prominent after reheating. The authors have studied these lines by subjecting wedge-shaped specimens to compression and comparing the results obtained with those produced in similarly treated specimens of copper. Twins of the usual kind have not hitherto been produced in Mn-steel, and the authors have only succeeded in developing them by very severe deformation followed by annealing, polishing, and re-deforming. In strong contrast with the difficulty of causing typical twinning in Mn-steel is the ease with which twins are produced in an iron alloy containing 33 % of Mn. The simple deformation caused by sawing is sufficient to cause the formation of twins after annealing at 1100° C. The experimental results indicate that the "manganese-steel lines" are twins and not slip-bands, because they begin and develop like the slip-bands in other metals and bear to the twins in Mn-steel the same relation as regards order of magnitude that the slip-bands bear to the twins in copper and even a 25 % Ni-steel. The lines result directly from deformation by quiescent stress and are thus mechanical, whereas twinning is rarely purely mechanical, but is usually only induced after suitable annealing. The formation of the Mn-steel lines is accompanied by an increase in the

Brinell hardness and by the metal becoming slightly ferromagnetic. This indicates that some of the metal is transferred to the alpha state, and the increase of hardness is to be referred to the partial amorphisation of this α-iron caused by slip, since it could not take place by the process of twinning. The persistency of the lines after reheating is due to the precipitation of cementite along them. F. C. A. H. L.

941. *Chemical and Mechanical Relations of Iron, Cobalt, and Carbon.* **J. O. Arnold** and **A. A. Read.** (Inst. Mech. Eng., J. 4. pp. 247–262; Disc. pp. 262–280, April, 1915. Engineering, 99. pp. 362–364, March 26, 1915. Mech. Eng. 35. pp. 282–284, April 9, 1915. Abstract.)—A brief summary of the work of previous investigators is given. Five alloys, containing from 2·68 to 20·85 % Co and 0·62 to 0·93 % C, were prepared and tested in the forged condition, since it was considered that normalising the steels might result in the precipitation of graphite. All the alloys machined readily. On account of the variation in the carbon-contents of the various alloys it is difficult to summarise the exact effect of Co on the static mechanical properties and the dynamic properties as determined by the Arnold test. The results, however, appear to indicate that cobalt increases the yield-point and the ultimate strength and decreases the ductility, while increase in the Co-content decreases the resistance to alternating stresses. Examination of the carbide residue after solution in dilute hydrochloric acid showed that the major portion of the Co existed in solution in the iron, only about 5 % of the amount present in the steel existing in combination with carbon. In the low-Co steels, annealing has little effect on the carbon, but as the Co-content increases more and more of the carbon is precipitated as graphite. In comparing Ni-steels with Co-steels it is shown that Co is not nearly so great a graphite precipitator as Ni, which points to cobalt carbide being a more stable compound than the carbide of nickel. Unlike Ni, Co does not form a definite compound with iron, and, further, while the whole of the Co-steels are readily machinable, there is in the Ni series a range of alloys which cannot be machined. F. C. A. H. L.

942. *Eutectoid Transition-point of Carbon Steels.* **S. W. J. Smith** and **J. Guild.** (Roy. Soc., Phil. Trans. 215. pp. 177–204, 1915.)—A description of thermomagnetic experiments on a series of steels with carbon content varying between 0·15 and 1·53 %. The discussion is confined to phenomena observed in the neighbourhood of 700° C., when steel containing about 0·9 % of carbon changes, during cooling, from an apparently homogeneous material into a heterogeneous eutectoid mixture of apparently pure iron and the carbide Fe_3C. The same change takes place in other steels, but is preceded by the separation, at higher temperatures, of the carbide or of iron, according as the steel contains more or less than the eutectoid percentage of carbon. The specimens were cut in the form of tubes 7 cm. long, and were examined by the magnetometric method while the temperature was raised to 800° and lowered. All the steels began to lose magnetism at the same temperature, viz. about 733° C. This accords with the view that the eutectoid always has the same composition. The temperature of return of magnetism is not constant, except perhaps in the case of the hypereutectoid steels. By considering the difference between the heating- and cooling-curves, a method is suggested for estimating the percentage composition of the eutectoid, on the basis that the contribution of the eutectoid to the total magnetism corresponds with the amount of iron which it contains. With steels richer in carbon, however, the eutectoid iron was found to contribute more than its calculated share to the total magnetisation. This discrepancy is discussed in relation to the shortness of the specimen, the effects of incomplete equilibrium within the cooling alloy (arising from the slowness of diffusion), and the effects of pressure. A working hypothesis as to the mode of crystallisation of the eutectoid is then described and applied to explain the form of the curves. It is concluded that by suitable adjustment of the field in any particular case the thermomagnetic method can be used to indicate the change-point Ac_1 with an accuracy that can scarcely be exceeded by any other method. Also, subject to limitations, iron crystals, carbide crystals, and a solid solution of uniform eutectoid composition cannot coexist without change except at a definite temperature. The magnetic field intensity does not appear to have any influence on the process of crystallisation. G. E. A.

943. *Tensile Properties of Copper at High Temperatures.* **G. D. Bengough** and **D. Hanson.** (Inst. of Metals, J. 12. pp. 56–76; Comm. 77–88, 1914. Engineering, 98. pp. 356–360, Sept. 18, 1914.)—Gives details of alterations made to a testing machine for the present series of tests, with which it was possible to vary the nature of the atmosphere in which the tests were carried out. The nature of the atmosphere is found to have important effects on the results, an oxidising atmosphere at high temperatures giving high ductility. Pure unannealed rolled copper maintains its superior strength over annealed copper at all temperatures from atmospheric to 1000°. Annealed copper preserves its superior ductility to approximately the same temperature. In the case of pure annealed copper, fracture passes through the crystals at all temperatures below about 700°, but at all temperatures above 750° it passes between the crystals. Between 700° and 750° it may take either course, though preferentially it is intercrystalline. The results of the tensile tests can be satisfactorily explained on the basis of Rosenhain's theory of cement surrounding the crystals, which cement is stronger than the crystals at low temperatures but weaker at high temperatures. The existence of a range of low ductility at about 250° to 450° as previously reported is confirmed. The effect of introducing either oxygen or arsenic into the copper is to lower the tensile strength at high temperatures but also to increase the ductility. Bars tested in hydrogen at temperatures about 720° are weaker than bars tested in neutral or oxidising atmospheres. This is probably due to the reduction of copper oxide. C. O. B.

944. *The Hardening of Metals. A General Discussion.* (Faraday Soc., Trans. 10. pp. 207–293, May, 1915.)—This discussion comprises an introductory address by **R. A. Hadfield,** an introductory paper by **G. T. Beilby,** and the following contributions:—Influence of allotropy on the metastability of metals, by **E. Cohen**; Amorphous phase in the hardening of steels, by **J. C. W. Humfrey**; Hardening of metals by quenching, by **C. A. Edwards**; Hardness of solid solutions and martensitic structure, by **C. H. Desch**; Interstrain theory of hardness, by **A. McCance**; Metallic filings, by **T. M. Lowry** and **R. G. Parker.** L. H. W.

945. *Behaviour of Slag occluded in Steel.* II. *Supposed Solubility of Inclusions of Slag in Liquid Steel.* **F. Giolitti** and **G. Tavanti.** (Ann. Chim. Applicata, 2. pp. 360–366, 1914.)—Examination of the condition and quantity of the reaction slag occluded in a small mass of steel cooled rapidly from the fused state, and of that occluded in the same mass after re-heating, followed by slow or rapid cooling, renders untenable the theory of the solubility of this slag in the steel at a high temperature. A marked difference exists between the behaviour of the reaction slag and that of inclusions consisting largely of sulphides of iron and manganese. T. H. P.

946. *Kinetics of Photochemical Reactions.* **D. Berthelot.** (Comptes Rendus, 160. pp. 519–522, April 19, 1915.)—A discussion of the energy transfers involving Planck's hypothesis of quanta. E. H. B.

947. *Kinetic Interpretation of Osmotic Pressure.* **P. Ehrenfest.** (K. Akad. Amsterdam, Proc. 17. pp. 1241–1245, June 3, 1915.)—The author gives a mathematical deduction of the osmotic pressure laws on a kinetic basis. A. F.

948. *Hydration of Ions and Hydrodiffusion of Electrolytes.* **G. McP. Smith.** (Am. Chem. Soc., J. 37. pp. 722–733, April, 1915.)—In the case of non-electrolytes the diffusion coefficient is related to the molecular weight according to a formula $DM^{n-1} = K$, where n and K are arbitrary constants. This law has been applied to the diffusion of metals in mercury and has revealed the existence of compounds such as $CuHg_3$, $NaHg_5$, KHg_6, $CaHg_5$, $SrHg_6$, $BaHg_6$, whilst Zn, Cd, Sn, Pb remain uncombined in their amalgams. Applying the same method to the mobilities of the ions, *i.e.* to the rate of diffusion under a known potential gradient, and calculating the constants on the assumption that H carries $2H_2O$ and OH carries $3H_2O$, the molecular hydrations of other univalent ions at great dilution are calculated to be as follows:—

H	OH	Cs	Br	Rb	I	Tl	Cl	NH_4	K	NO_3	SCN	ClO_3
[2·0]	[3·0]	3·7	6·7	6·4	4·3	0·15	9·6	10·7	9·6	8·9	10·3	9·2
2·0		*9·9*					*[9·00]*		*10·5*			

Ag	BrO_3	F	Na	IO_3	Cl
8·2	9·3	15·7	16·9	14·1	24·0
			16·6		*25·3*

The figures in italics are values deduced by Washburn and others from experiments on the transportation of water in electrolysis, assuming that Cl carries $9H_2O$. If these values are used to determine the real molecular weights of the hydrated ions, it is found that the hydrodiffusion of electrolytes (*i.e.* the spontaneous diffusion without any external e.m.f.) is no more complicated than that of non-electrolytes, since it obeys the same law $DM^{n-1} = K$. This law has now been shown to apply to the hydrodiffusion of organic compounds under 3 different sets of conditions, to the hydrodiffusion of gases, to the diffusion of metals and metallic compounds in mercury, to the hydrodiffusion of hydrated electrolytes, and finally to the independent diffusion of hydrated ions; the constants used in each case are tabulated at the end of the paper. T. M. L.

949. *Properties of Silver Iodide interpreted in Relation to Recent Thermodynamic Conceptions.* **G. Jones** and **M. L. Hartmann.** (Am. Chem. Soc., J. 37. pp. 752–775, April, 1915.)—The e.m.f. of silver-silver iodide-iodine cells was measured at 0° and 25°. From the data thus obtained the free energy of formation of silver iodide from silver and iodine was calculated to be 65·1 kilojoules at 0°, and 66·1 kilojoules at 25°. These measurements show that the affinity of silver and iodine for each other increases with rising temperature, which makes possible a plausible explanation of the negative coefficient of expansion of silver iodide, and thus supports the analysis of coefficients of expansion based on the Richards hypothesis of compressible atoms. The heat of formation of silver iodide is 61·0 kilojoules.

The relationships between the properties and thermodynamic constants of silver iodide support many conclusions which Richards drew from his hypothesis of compressible atoms, but they do not support the second of the assumptions which Nernst applied to these conclusions commonly known as the Nernst heat theorem; the best way to test these assumptions is by means of accurate determinations of the temperature-coefficient of free energy. T. M. L.

950. *Entropy of Vaporisation as a Means of distinguishing Normal Liquids.* **J. H. Hildebrand.** (Am. Chem. Soc., J. 37. pp. 970–978, May, 1915.)—The entropy of vaporisation (*i.e.* the molecular heat of vaporisation divided by the absolute temperature at which vaporisation takes place) is the same for all normal liquids, not, as in Trouton's rule, when the vaporisation takes place at the same pressure (1 atmo.), but when it takes place at the same concentration of vapour.

This fact may be expressed in the form of a vapour-pressure equation containing a single constant characteristic of the liquid, this constant being determined from the temperatures necessary to give the same concentration of vapour in the different cases. T. M. L.

951. *The Wet Oxidation of Metals.* III, *The Corrosion of Lead.* **B. Lambert** and **H. E. Cullis.** (Chem. Soc., J. 107. pp. 210–218, Feb. 1915.)—Pure lead prepared by Stas's method and distilled *in vacuo* resembles silver in appearance but tarnishes rapidly if exposed to air a short time after distillation. When exposed to pure water and pure oxygen under the conditions laid down in Abs. 782 (1912), freshly prepared lead undergoes very rapid corrosion. If, however, the lead is kept under water for a long time in a vacuum the rate of corrosion is enormously decreased. These results indicate that freshly distilled lead is not physically homogeneous, but tends to become so when kept for long periods *in vacuo.* It is this physical heterogeneity which results in electrical differences throughout the mass of lead and sets up corrosion. Hydrogen peroxide is produced during the wet oxidation of lead. It is, however, only a secondary product, and has no direct bearing on the process of corrosion, but it does play a part in oxidising the monoxide to higher oxides. F. C. A. H. L.

952. *Changes of Volume occurring in the Dissolution o, Certain Solids.* **A. Cavazzi.** (Gazzetta Soc. Chim. Ital. 44. 1. pp. 448–468, 1914.)—The author has measured the changes in volume occurring when a number of salts and acids and sucrose are dissolved in water, and when crystalline copper sulphate is dissolved in ammonia solution, sulphur or iodine in carbon disulphide, or iodine in ether. The measurements were made at 15°, and the numerical results, which are given in full, lead to the following conclusions.

The specific gravity of substances in solution gradually diminishes as the concentration increases, and this happens also with anhydrous salts, especially when the concentrations giving diminutions in volume are surpassed, that is, when the specific gravities of the solutes assume positive values. The predominating cause of this variation of the specific gravity of solutes, particularly with substances which under ordinary conditions separate from solution in an anhydrous state, is the dissociation, but the specific gravities of sucrose in water and of sulphur in carbon disulphide are sensibly greater in dilute than in concentrated solutions. Of all the compounds examined ammonium chloride is the only one which has the same specific gravity in very dilute solution as in the solid state, but here, too, diminution accompanies increasing concentration. T. H. P.

953. *Electrostatics in Relation to Mass-action in Electrolytic Solutions.* **R. T. Lattey.** (Chem. News, 111. pp. 185–186, March 19, 1915.)—Some doubt has arisen as to whether the law of mass-action would be valid when applied to the dissociation of electrically neutral molecules into oppositely charged ions. An investigation of the electrostatic conditions which are involved shows that the electrical equilibrium is identical in form with the chemical equilibrum, and does not interfere with the ordinary laws of mass-action. T. M. L.

954. *A Theory of Supersaturation.* **W. J. Jones** and **J. R. Partington.** (Phil. Mag. 29. pp. 35–40, Jan., 1915.)—A consideration of the surface-energy at the boundary between a solid and its saturation leads to a theory of supersaturation depending on the variation of solubility with the radius of curvature of the solid particles. This theory leads to the following properties of supersaturated solutions:—(1) A solution may contain more solute than corresponds with equilibrium in contact with a plane surface of solid solute. (2) Such a "supersaturated" solution can be in equilibrium with particles of solid of a definite size. Smaller particles dissolve in the solution, larger particles bring about its crystallisation. (3) According as the solid dissolves in its nearly saturated solution with absorption or evolution of heat, the size of "active" particles of solid, *i.e.* such as induce crystallisation in a given solution, decreases with fall of temperature, or rise of temperature respectively. (4) The solution may, at a sufficiently low or high temperature, respectively, crystallise spontaneously. T. M. L.

955. *Radiometric Measurements of the Ionisation Constants of Indicators.* **E. J. Shaeffer, M. G. Paulus** and **H. C. Jones.** (Am. Chem. Soc., J. 37. pp. 776–807, April, 1915.)—By using a radiomicrometer, having a half-period of 10 sec. and a sensibility of 5 per mm. of exposed vane, and a grating spectroscope, a radiometric method was worked out for the determination of the ionisation constants of indicators. This method is freer from objections and limitations than any method previously used and serves as well for a two-coloured indicator as for a one-coloured indicator. Very small concentrations of coloured components, and minute concentrations of hydrogen and hydroxyl ions can be quickly and accurately estimated by radiometric measurements. The ionisation of methyl orange as a base was measured and the constant was found to be $2{\cdot}1 \times 10^{-11}$; but the ionisation and hydrolysis constants for phenolphthalein considered as a monobasic acid were far from being satisfactory. From the known ionisation constant of methyl orange and from radiometric measurements, the ionisation constant of a very weak base and the hydrolysis constant of one of its salts have been roughly determined. The method can likewise be applied for the determination of the ionisation constants of very weak acids, and the hydrolysis constants of the salts formed by these acids. T. M. L.

956. *Influence of Alternating Current on Electrolysis by Direct Current.* II. **J. C. Ghosh.** (Am. Chem. Soc., J. 37. pp. 733–752, April, 1915.)—1. When an alternating current of high frequency, about 30,000 per min., passes through a cell consisting of two Pt electrodes dipped in any electrolyte, the electrode potentials change, thus indicating that some chemical action at the electrode surface takes place in that short amount of time. 2. When an alternating current passes through a reversible voltaic cell there is no change in the electrode potential. If, however, one of the electrodes consists of a metal

covered with its insoluble salts, the alternating current has pronounced effect on that electrode. 3. A greater amount of current can be supplied by a cell with one reversible and another irreversible electrode, when an alternating current plays in the circuit. 4. In cells like Cd–ZnCl$_2$–Hg, Cd–ZnCl$_2$–Pt, etc., the e.m.f. of the Hg or Pt electrode approaches the value of the zinc electrode on the passage of the alternating current. 5. In perfectly reversible electrolytic cells the alternating current has no action when impressed on the cell along with a direct current; but if the electrolytic cell be irreversible, the alternating current greatly increases the current strength through the circuit, owing to a diminution in the back electromotive force of polarisation. A similar diminution in the discharge potential is also observed in electrolytic cells consisting of two kathodes and two anodes, the alternating current playing between the anodes or the kathodes, but not passing through the whole circuit. [Compare Abs. No. 148 (1915).] T. M. L.

957. *Reproducibility of the Cadmium Electrode.* **F. H. Getman** and **V. L. Gibbons.** (Am. Chem. Soc., J. 37. pp. 953–970, May, 1915.)—Neither freshly-cast rods of Cd nor spongy Cd deposited electrolytically are reproducible when set up in a concentration cell against cadmium iodide dissolved in methyl alcohol; freshly-cast rods are also not reproducible when used as electrodes in aqueous cadmium iodide, but rods which have become grey by standing in solutions of cadmium iodide give constant e.m.f.'s; freshly-cast rods work gradually towards an identical value, but inoculation experiments show that the action is extremely slow. This behaviour is attributed to allotropic changes.

Crystalline electrolytic Cd is reproducible, but gives slightly higher e.m.f.'s than the grey Cd electrodes. Amalgamated electrodes are not reproducible.

Photomicrographs confirm the conclusions drawn from the measurements of e.m.f., as they show a definite change of crystalline form; they also prove that the changes are caused by a deposit on the surface and not by a pitting of the metal. T. M. L.

958. *Ionisation-equilibrium.* **J. Kendall.** (J. Phys. Chem. 19. pp. 193–209, March, 1915. Paper read before the New York Academy of Sciences, Nov., 1914.)—A critical investigation of the divergences from the dilution law exhibited by acids in aqueous solution has shown that the *increase* in the dissociation constant when the *ionic concentration* is large can be represented quantitatively by the equation: $\gamma^2/(1-\gamma) \,.\, v = k + c(1-\gamma)/\gamma$. This empirical formula is applicable to acids of all strengths. The *decrease* in the dissociation constant when the *total concentration* is large is found to disappear under the assumption that ionisation is not spontaneous, but induced by the solvent. The legitimacy of this assumption is discussed, and the experimental data are shown to support it. The dissociating power of the solvent is ascribed to its unsaturated character, *i.e.* to the presence of free valences. T. M. L.

959. *Anode Complications in the Silver Voltameter.* **T. W. Richards** and **F. O. Anderegg.** (Am. Chem. Soc., J. 37. pp. 675–693, April, 1915.)—The results of experiments confirm earlier results of the authors, and also those of Hulett, that the anode liquid may really augment the weight of the ignited kathode deposit even when no filter-paper is present. This effect is presumably due to metastably dissolved silver, in the form of an argentous ion, but the mechanism of the effect is not yet fully elucidated. An illusory

agreement between different forms of voltameter was found in some uncorrected experiments, because of the balanced effect of two errors, inclusion and surcharge. By comparing the weights of the ignited precipitates, this compensating effect could be detected and analysed. These and other questions concerning the voltameter are being further investigated experimentally. F. E. S.

960. *Maximum Efficiency in Aluminium Electrolytic Rectifiers.* **G. Schulze.** (Archiv f. Elektrot. 3. pp. 48–48, 1914.)—A general article with especial reference to experiments with electrodes of Al and of Ta. Rectifiers for low potentials and small currents are still lacking, since the mercury rectifier will hardly work at less than 2·5 amps. and 12 volts. In electrolytic rectifiers losses arise from three causes : (1) The current does not flow before a minimum potential is exceeded ; (2) the valve effect (cutting out the current in one direction) is incomplete, and (3) the electrolyte has an ohmic resistance ; only these latter two losses can be diminished. The author calculates the max. possible efficiency of an Al rectifier for the transformer arrangement and for the Grätz arrangement (always 2 cells in series), and discusses the minimum potential with especial regard to Ta cells. This potential depends little upon the anion, much upon the kathion, as which the alkali metals answer best ; mixtures of electrolytes allow of working at low potentials. As to formation, direct current and alternating current behave differently in different electrolytes. To secure the max. efficiency rectifiers should be formed (by direct current) at less than 90 volts when in the transformer arrangement, and at more than 90 volts when in the Grätz arrangement. With good electrolytes ($NaNH_4 . HPO_4$, $NaHCO_3$, acid sodium citrate) and good cooling efficiencies of up to 80 per cent. should be realised ; H_3AsO_4 and ammonium salts like $(NH_4)_2HBO_3$ are quite unsuitable ; $Na_2B_4O_4$ is improved by the addition of H_3PO_4. $NaNH_4 . HPO_4$ is much preferable to Na_2HPO_4. For low potentials the efficiencies are low. The ohmic losses increase with time, since they take place in the skin of hydroxide on the electrode, which skin becomes thicker as the rectifier is used. Aluminium rectifiers should, hence, not be mounted in places difficult of access, but the plates should be cleaned and rubbed with emery paper at frequent intervals and be re-formed ; the treatment of a rectifier should thus be similar to that of an arc lamp with renewable carbons. H. B.

961. *Electrolysis of Barium Chloride Solutions with Mercury Kathodes.* **P. P. Feodotieff** and **I. Weizer.** (Zeitschr. anorg. Chem. 86. pp. 325–337, 1914.)—The preparation of barium compounds is best started by the electrolysis of $BaCl_2$, which differs little from that of the alkali chlorides, except that the barium amalgam is more stable than the alkali amalgam and the barium hydrate, obtained by decomposition of the amalgam, less soluble in water than caustic alkali. Weizer studies the processes of Kellner, modified by Solvay, and of Castner. In the former the amalgam has to be transferred to a separate vessel for decomposition, which is accelerated by the presence of iron at 60° C. The efficiency increased as the current density was raised up to 0·06 amp./cm.^{2}. The Castner arrangement, in which the mercury bottom is common to the electrolytic and the decomposition cell, is less suitable because the barium hydrate is sparely soluble ; a good efficiency is, however, also realised at 40° C. and not too small a current density above 3 volts. H. B.